ENTOMON

CONTENTS

PIPERONYL BUTOXIDE AS A COUNTERMEASURE FOR DELTAMETHRIN – RESISTANCE IN *CULEX QUINQUEFASCIATUS* SAY

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Continuous larval selections of *Culex quinquefasciatus* for 40 generations with the synthetic pyrethroid, deltamethrin resulted in 1449-fold resistance to deltamethrin. When the larvae were subjected to selection pressure of deltamethrin and the synergist, piperonyl butoxide (PBO) in the ratio of 1:5, the speed of selection for deltamethrin resistance in the larvae slowed down considerably by 17 to 63%. In a parallel selection study, 137-fold deltamethrin resistant strain when subjected to continuous selection pressure with synergised deltamethrin, initially showed 76% reversion in deltamethrin resistance in the first generation and significantly retarded the development of deltamethrin resistance in subsequent generations. The present data clearly indicate the efficacy of PBO in enhancing the usefulness of deltamethrin. Deltamethrin selection caused cross-resistance to DDT suggesting the probable involvement of *kdr* gene in this strain.

(*Key words*: deltamethrin, *Cx. quinquefasciatus*, resistance, piperonylbutoxide, DDT, synergists)

INTRODUCTION

Among the new generation of synthetic pyrethroids, deltamethrin excels others in its insecticidal efficacy (ELLIOTT *et al.*, 1974). Besides, deltamethrin is photostable and has very low mammalian toxicity due to its high vulnerability to enzymatic degradation. These excellent favourable features have made deltamethrin an effective substitute insecticide in mosquito abatement programmes (PRIESTER & GEORGHIOU, 1980; RAJVANSHI *et al.*, 1982). The efficacy of deltamethrin as a larvicide and an adulticide against the tropical house mosquito, *Culex quinquefasciatus* has already been documented (PRIESTER & GEORGHIOU, 1980; RAJVANSHI *et al.*, 1982; DAS & KALYANASUNDARAM, 1984). However, its potency to select for resistance has not been fully ascertained. Such an information is a prerequisite to develop strategies to maximise its efficacy in the field. It is well established that piperonyl butoxide (PBO) is an effective synergist for natural pyrethrins and synthetic pyrethroids due to its ability to inhibit the pivotal detoxifying enzymes, the monooxygenases (CASIDA, 1970; JAO & CASIDA, 1974). In this context, it was thought of interest to assess the impact of PBO on the development of deltamethrin resistance in *Cx. quinquefasciatus*. Thus, the present studies were aimed to evaluate by laboratory selection, the speed of selection for resistance to deltamethrin in the larvae and adults of *Cx. quinquefasciatus* and also to evaluate the potency of PBO to counteract deltamethrin resistance.

MATERIALS AND METHODS

For the present studies, mosquito larvae and adults were drawn from a laboratory colony of *Cx. quinquefasciatus*. This colony originated from field-collected engorged female adults of *Cx. quinquefasciatus* which

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were maintained in cloth cages in an insectary at $28 \pm 1°C$ and $80 \pm 5\%$ RH with a photoperiod of 14 h of daylight and 10 h of darkness, as described by BAKSHI *et al.* (1982). The adult females were blood-fed on alternate days by providing a restrained albino rat in the cage overnight. Eggs were collected in ovitraps kept in the cages and the larvae were reared in enamel trays and fed on finely powdered dog biscuits and yeast in the ratio of 3:2. Pupae formed were collected in small enamel bowls and kept in the cages for adult emergence (THOMAS & PILLAI, 1986).

The insecticides used in the present studies include:

carbaryl: 1–naphthyl–N–methyl carbamate, 99.5% pure;

carbofuran: 2,3–dihydro–2,2–dimethyl–7–benzofuranyl methyl carbamate, 99.0% pure;

p, p' – DDT: 1,1,1–trichloro-2,2–*bis* (*p*-chlorophenyl) ethane, 99.0% pure;

deltamethrin: (s)α–cyano–3–phenoxybenzyl *cis*–(1R)-3-   (2,2–dibromovinyl)   –2,2–dimethyl cyclopropane carboxylate, 98.8% pure;

endosulfan: 6, 7, 8, 9, 10–hexachloro–1,5,5a, 6, 9, 9a – hexahydro– 6, 9–methano–2, 4, 3 – benzadioxathiepin - 3-oxide, 95.0% pure;

fenitrothion: 0, 0–dimethyl–0–(4–nitro–m–tolyl) phosphorothioate, 98.0% pure;

fenthion: 0,0–dimethyl– 0 –[(4–methyl thio) m–tolyl] phosphorothioate, 98.4% pure;

lindane: 1,2,3,4,5, 6– hexachlorocyclohexane, 99.0% pure;

malathion: 0,0–dimethyl 5– (1,2– dicarboxyethyl) phosphorodithioate, 84% pure;

permethrin: 3–phenoxybenzyl3–(2,2–dichlorovinyl)–2,2–dimethylcyclopropane carboxylate, cis: trans, 25:75%;

propoxur: 0–isopropoxyphenyl –methylcarbamate, 99.0% pure;

temephos: 0,0–dimethyl phosphorothioate 0,0–diester with 4, 4–thiodiphenol, 94.0% pure;

piperonyl butoxide (PBO): 5–[2–(2–butoxy ethoxy) methyl] 1, 3– benzodioxole.

Deltamethrin (0.025%) and DDT (4%) impregnated papers were obtained from World Health Organization, Geneva.

Bioassay:

Susceptibility tests were carried out with early fourth instar larvae using 24th exposure according to the WHO standard test for mosquito larvae (WHO, 1981a). Batches of 25 larvae were exposed to ethanolic solutions of the insecticide in 250 ml of water taken in glass jars. Controls were treated with ethanol alone, and control mortality, if any, was corrected using Abbott's formula (ABBOTT, 1925).

Exposure of 3-day old blood-fed females was carried out by the procedure recommended by WHO using WHO test kit (WHO, 1981b). Sets of 20 mosquitoes were exposed to impregnated papers of deltamethrin (0.025%) and DDT (4%) separately for varying durations, and held for 24 h after which mortalities were recorded and corrected for control mortality.

Selection :

Early fourth instar larvae (ca. 200) were treated for 24 h in glass jars containing 249 ml of water and 1 ml of the appropriate insecticide solution in ethanol (CHITRA & PILLAI, 1984). In each selection, the insecti-

cide concentration was so adjusted as to result in 80 to 90% larval mortality. For each selection, 2000–3000 larvae were used. The larvae surviving after 24 h were thoroughly washed and reared to adults. The larvae of the next generation were tested and further selected with appropriate LC_{90} dose. The selections were continued for successive generations. Thus, the parental susceptible strain of *Cx. quinquefasciatus* was subjected to selection pressure at the larval stage with deltamethrin alone for 40 generations, and separately with deltamethrin and PBO (1:5) for 20 generations. In addition, the larvae of the F_{24} deltamethrin-selected strain were subjected to a parallel selection with deltamethrin and PBO (1:5) till 40 generations. For comparison, larvae of the susceptible strain were also selected with DDT for 40 generations.

The mortality data were subjected to regression analyses of probit-mortality on log dosage and the LC_{50}, LC_{90}, slope and heterogeneity (χ^2) about the linear regression line were computed (FINNEY, 1971). Resistance ratios were calculated by dividing the LC_{50} value of the resistant strain by the LC_{50} value of the susceptible population.

Larvae of the deltamethrin larval-selected and synergised selection strains were tested with several organochlorine, organo-phosphorous and carbamate insecticides twice during selection studies and their cross-resistance ratios were calculated.

Selection of adults was performed using the WHO adult susceptibility kits, according to the method of CHADWICK *et al.* (1984). Several batches of 20–25 fully blood-fed mated females were exposed to 0.025% deltamethrin (discriminatory dose recommended by WHO) for different time intervals in order to cause 90% adult mortality.

This was followed by a 24 h holding period and the survivors were separated and transferred to cloth cages. The eggs laid by the selected females were reared to adults. The selection pressure was continued for 40 generations. Resistance ratios were calculated as described above.

RESULTS

Table 1 gives the larval susceptibility of the parental susceptible strain of *Cx. quinquefasciatus* to various insecticides. As evident from the data, deltamethrin proved to be 1168 to 1981-fold more toxic than the organochlorine, 42 to 1128 than the organophosphorous and 14 to 3136 than the carbamate insecticides tested. Besides, deltamethrin was much more toxic to the adult mosquitoes when exposed to deltamethrin impregnated papers, as it caused almost instantaneous-mortality. The LT_{50} value was significantly lower than that of DDT, even though 4% DDT impregnated paper was used (Table 2).

When the larvae of *Cx. quinquefasciatus* were selected with deltamethrin alone for 40 generations, the development of resistance was very slow till the F_{10} generation as it showed only 34-fold resistance (Table 3; Fig. 1). However, from F_{10} to F_{20}, there was a steady increase as the larvae attained 137–fold resistance to deltamethrin in 20 generations. It is apparent from the data that from F_{20} to F_{40}, selections caused an alarming rise in the level of resistance, which resulted in 1449-fold resistance to deltamethrin in the F_{40} larvae (Table 3).

A parallel selection of the susceptible larvae with deltamethrin and PBO in 1:5 proportion exhibited a much slower rate of development of deltamethrin resistance in *Cx. quinquefasciatus* (Table 3; Fig. 1). Selections with PBO did not show much change in resistance upto F_{10} generation

TABLE 1.   Larval LC$_{50}$ (ppm) of *Cx. quinquefasciatus* to various insecticides.

Insecticide	LC$_{50}$	Slope $\pm$ S E	Heterogeneity χ^2 (df)	
deltamethrin	0.000121	2.208 $\pm$ 0.15	7.37	(3)
permethrin	0.004861	1.504 $\pm$ 0.13	4.01	(3)
DDT	0.1414	1.933 $\pm$ 0.19	7.88	(4)
lindane	0.2299	1.858 $\pm$ 0.16	5.35	(3)
endosulfan	0.2397	2.320 $\pm$ 0.18	5.45	(3)
malathion	0.0175	1.319 $\pm$ 0.10	26.29	(3)
fenthion	0.1365	4.060 $\pm$ 0.32	1.03	(2)
fenitrothion	0.0051	1.760 $\pm$ 0.16	4.75	(4)
temephos	0.0017	2.592 $\pm$ 0.25	3.65	(4)
carbofuran	0.0412	3.035 $\pm$ 0.28	6.49	(4)
carbaryl	0.3794	3.543 $\pm$ 0.32	5.14	(2)
propoxur	0.1708	3.903 $\pm$ 0.31	0.31	(2)

TABLE 2:   Susceptibility of adult females of *Cx. quinquefasciatus* to 0.025% deltamethrin* and 4% DDT* impregnated papers expressed as LT$_{50}$ and LT$_{90}$ (in min).

Insecticide	LT$_{50}$	LT$_{90}$	Slope $\pm$ SE	Heterogeneity χ^2 (df)	
deltamethrin	5.7 (4.6 — 7.2)**	35.2 (23.6 — 52.2)**	1.626 $\pm$ 0.14	8.49	(6)
DDT	74.4 (59.4 — 93.2)**	222.5 (150.9 — 328.1)**	2.695 $\pm$ 0.40	4.28	(3)

*   Discriminatory dosages recommended by WHO.

**   Figures in parentheses indicate the lower and upper 95% fiducial limits.

as compared to selections with deltamethrin alone. Selections with the synergist from F_{10} to F_{20} produced only 51-fold resistance to deltamethrin as against 137-fold deltamethrin resistance observed in F_{20} deltamethrin-slected strain (Table 3). The data thus reveal a progressive suppression in the development of deltamethrin resistance from F_{10} to F_{20} as a result of selection with the synergist, and the level of retardation in the development of resistance increased from 36 to 63% (Table 3).

When the deltamethrin resistant F_{24} strain with 327-fold resistance was selected with deltamethrin and PBO, there was a dramatic reduction in the level of resistance to deltamethrin. In one generation, the
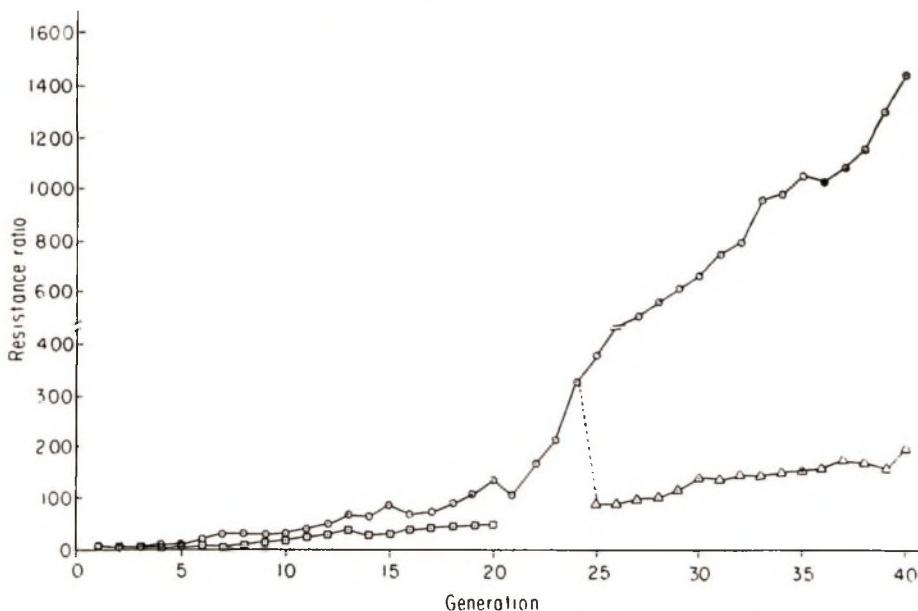
Fig. 1. Development of deltamethrin resistance in the larvae of *Cx. quinquefasciatus* (indicated as resistanee ratios) wnen continuously selected with deltamethrin alone or with deltamethrin plus PBO in 1:5 ratio. Selected with deltamethrin alone (circles); with deltamethrin plus PBO from the parental strain (squares); and from F_{24} deltamethrin-resistant strain (triangles).

resistance ratio declined to 90 indicating almost 76% reversion of deltamethrin resistance (Table 3, Fig. 1). Subsequent selections with the synergist till F_{40} showed only a gradual increase in the level of deltamethrin resistance from 90 to 196-fold as against 378 to 1449-fold observed in parallel selections with deltamethrin alone (Table 3). Also, the impact of PBO on the development of deltamethrin resistance enhanced with each selection, as the per cent suppression of deltamethrn resistance increased from 76 in F_{24} to 86.5 in F_{40} (Table 3).

Selection with DDT for 40 generations registered only about 200-fold resistance despite the larvae of the F_{40} generation attaining an LC_{50} value of more than 28 ppm (Table 3). Similar selections with deltamethrin alone and with deltamethrin and PBO showed LC_{50} values to deltamethrin of only 0.175 and 0.02 ppm, respectively, which were, in fact, 161 and 1227 times less than the LC_{50} for DDT in the F_{40} selected strains.

It is apparent from Table 4 that the larval selections of *Cx. quinquefasciatus* with deltamethrin for 40 generations did not produce any appreciable degree of cross-resistance to many carbamates, OP compounds, permethrin and organochlorines tested, the only exception being DDT. The data revealed that the F_{40} deltamethrin selected strain showed 342-fold cross-resistance to DDT, while deltamethrin and PBO selected strain exhibited about 152-fold at F_{20} and 344-fold at F_{40} generations (Table 4).

Selection of adult, unlike, the larvae, with deltamethrin-impregnated papers for 40 generations caused only a 4-fold increase in tolerance to deltamethrin (Table 5).

DISCUSSION

The present data demonstrate the superior larvicidal and adulticidal activity of deltamethrin against *Cx. quinquefasciatus,* as compared to many insecticides, including various potent OP compounds and perme-

TABLE 3. LC_{50} values (in ppm), resistance ratios and percentage suppression of deltamethrin resistance in strains of *Cx. quinquefasciatus* selected with deltamethrin and DDT.

Selecting agency	Parent	F_{10}	F_{20}	F_{24}	F_{25}	F_{30}	F_{40}
deltamethrin	0.000121	0.004114 (34.0)	0.016581 (137.0)	0.039579 (327.1)	0.045804 (378.5)	0.081571 (674.1)	0.175350) (1449.2
deltamethrin + PBO (1:5)	0.000100	0.002152 (21.5)	0.005124 (51.2)	—	—	—	—
% suppression in resistance	17.3	36.8	62.6	—	—	—	—
deltamethrin + PBO (1:5) from F_{24}	—	—	—	0.39579 (327.1)	0.010873 (89.9)	0.017321 (143.1)	0.023737 (196.2)
% suppression in resistance	—	—	—	—	76.2	78.8	86.5
DDT	0.1414	6.6973 (47.4)	13.2862 (94.0)	17.3373 (122.6)	17.6830 (125.0)	20.8346 (147.3)	28.2322 (199.7)

Figures in parentheses indicate the resistance ratios.

TABLE 4. Cross-resistance ratios for various insecticides in the larvae of insecticide–selected strains of *Cx. quinquefasciatus*.

Insecticide	Deltamethrin selected		Deltamethrin + PBO selected			
			From F_{24}		From the parent strain	
	F_{20}	F_{40}	F_{30}	F_{40}	F_{10}	F_{20}
permethrin	1.9	9.1	4.4	9.2	2.6	10.1
DDT	175.0	342.2	311.2	344.0	30.9	152.4
lindane	1.1	2.3	1.0	1.0	1.1	1.0
endosulfan	1.3	2.3	1.1	2.3	2.5	1.2
malathion	3.3	9.6	3.1	7.2	1.6	3.3
fenthion	1.1	1.3	1.8	1.7	1.0	0.4
fenitrothion	0.6	1.0	0.6	0.6	0.6	4.7
temephos	4.8	2.6	0.5	0.7	0.5	0.5
carbofuran	0.5	0.6	0.4	0.6	0.4	1.4
carbaryl	1.0	2.2	1.6	3.1	0.5	1.1
propoxur	1.1	1.6	1.6	1.3	0.6	1.4

TABLE 5. Development of resistance to deltamethrin in *Cx. quinquefasciatus* adults exposed to 0.025% deltamethrin-impregnated papers.

Generation of selection	LT_{50} (in min)	Slope $\pm$ SE	Resistance ratio
Parent	5.7	1.63 ± 0.14	—
F_{10}	14.3	1.80 ± 0.22	2.5
F_{20}	15.5	1.79 ± 0.23	2.7
F_{30}	20.1	2.33 ± 0.31	3.5
F_{40}	24.7	2.37 ± 0.29	4.3

thrin. Deltamethrin has also been found to be highly potent against an American strain of *Cx. quinquefasciatus*, the LC_{50} being 6-fold lower than that observed in the present studies (MULLA *et al.*, 1980). The authors earlier reported that deltamethrin was more toxic to *Cx. tarsalis* than permethrin, parathion and methyl parathion (MULLA *et al.*, 1978). On the other hand, the toxicity of deltamethrin against a laboratory strain of *Cx. quinquefasciatus* from India, as reported by RAJVANSHI *et al.* (1982) was about 10 times less than that observed in the present investigations. Nevertheless, deltamethrin susceptibility tests on American and Indian strains of *Cx. quinquefasciatus* by PRIESTER & GEORGHIOU (1980) as well as DAS & KALYANASUNDARAM (1984), respectively, exhibited almost identical results.

Deltamethrin demonstrated high adulticidal activity, surpassing that of DDT, as it was found to be 15–fold more toxic than DDT at the LT_{90} level. This is in agreement with the results reported by RETTICH (1982), wherein deltamethrin caused complete mortality of *Cx.p.pipiens* adults in 2 min at a concentration of 0.1 g/m², showing 30-fold greater activity as compared to DDT. In *Cx. fatigans*, total adult mortality was observed after 30 min of contact with 0.043 g/m² deltamethrin (NEVES *et al.*, 1981). DAS & KALYANASUNDARAM (1984) observed an LD_{50} of 0.1420 µg/cm² against the adults of a laboratory strain of *Cx. quinquefasciatus*, while a field strain was about 1.4 times less susceptible.

Continuous selection of *Cx. quinquefasciatus* larvae with deltamethrin alone for 40 generations caused an initial slow development in resistance but thereafter, the speed of selection showed a striking increase, thus attaining 1449-fold resistance to deltamethrin. In a report from France, selection of third instar larvae of *Cx. pipiens* at LC_{70} level led to an initial 9-fold rise in resistance after 9 generations, which increased to 22-fold at F_{23}, and remained stable at around 20 till 38 generations (GAVEN *et al.*, 1986). However, in a field trial of 2 years application of deltamethrin, SINEGRE (1984) observed the development of 30-fold deltamethrin resistance in the larvae of *Cx. quinquefasciatus*.

It is clear from the present data that selection of *Cx. quinquefasciatus* with deltamethrin in combination with PBO evidently slowed down the speed of selection for resistance to deltamethrin. Thus, 20 generations of selections with PBO exhibited 20 to 60-fold suppression of speed of development of resistance. However, a drastic reduction in deltamethrin resistance was evident when 327-fold deltamethrin resistant strain was selected with deltamethrin and PBO. The percentage reversion noticed was 76 in one generation. It is interesting to note that further selections with PBO indeed had a deleterious impact on the speed of selection for deltamethrin resistance. The rate of suppression increased from 76 to 86%. Identical selection studies by GAVEN *et al.* (1986) have shown that the application of deltamethrin along with PBO (1:10) on F_{10} deltamethrin resistant larvae of *Cx. pipiens* diminished the resistance level from 10 to 7 in a single generation. Subsequent selections delayed the development of resistance, reaching to only 11-fold in 38 generations as against 20-fold when selected with deltamethrin alone. The rate of suppression thus increased from 30 to 45% only. Earlier, RANASINGHE & GEORGHIOU (1979) have demonstrated that the selection of temephos resistant strain of *Cx. p. fatigans* with temephos plus TBPT reduced the resistance level from 7.8 to 5.5 - fold in one generation and further 9 generations of synergised selections retarded the resistance levels significantly

when compared to unsynergised selections. In *Aedes aegypti*, PILLAI *et al.* (1963) observed that selection of a Trinidad DDT-resistant strain with the WARF antiresistant plus DDT mixture (1:1) caused about 4-fold retardation in the resistance level to DDT. Thus, it is evident from the present data that PBO has the desired potency to retard the selection for deltamethrin resistance. This may be attributed to its ability to inhibit microsomal mono-oxygenases which are known to rapidly degrade the synthetic pyrethroids (CASIDA, 1970).

Though the larvae of *Cx. quinquefasciatus* could develop very high levels of resistance to deltamethrin, their LC_{50} levels in selected strains were significantly low when compared to DDT selection. It is well documented that the larvae of *Cx. quinquefasciatus* are capable of developing very high levels of resistance to DDT (KOSHI *et al.*, 1963; TADANO & BROWN, 1966).

A remarkable observation was that deltamethrin selection induced a high level of cross-resistance to DDT in *Cx. quinquefasciatus*. The larvae of deltamethrin selected strain, however did not exhibit any appreciable increase in cross-tolerance to any other insecticide tested. The cross-resistance spectrum of permethrin resistant *Cx. quinquefasciatus* has been shown to extend to DDT, deltamethrin and several other pyrethroids (PRIESTER & GEORGHIOU, 1980). This close association of deltamethrin and DDT resistance in *Cx. quinquefasciatus* indicates the possibility of *kdr* type of gene operating in this species. Earlier, PLAPP & HOYER (1968) suggested that the cross-resistance to pyrethrin in DDT-resistant *Cx. tarsalis* is due to the pleiotropism of *kdr* gene. However, a highly DDT-resistant strain of *Cx. quinquefasciatus* from Nigeria displayed very low levels of cross-tolerance to allethrin and bio-allethrin (RONGSRIYAM & BUSVINE, 1975). In the permethrin resistant strain of *Cx. quin-*

quefasciatus developed by PRIESTER & GEORGHIOU (1978), *kdr* was shown to contribute significantly to resistance toward both permethrin and DDT (HALLIDAY & GEORGHIOU, 1985). On the other hand, no direct involvement of *kdr* in deltamethrin resistance in *Cx. quinquefasciatus* has been reported to date. Nevertheless, in houseflies, SAWICKI *et al.* (1986) reported the involvement of a *super-kdr* gene in deltamethrin resistance, which was further enhanced by an intensifier, factor 161. The *super-kdr* gene and factor 161 together conferred immunity to deltamethrin in female houseflies, and lower levels of intensification to the other pyrethroids. On the contrary, in *Anopheles stephensi* the absence of a relationship between DDT and permethrin resistance indicates that the *kdr* mechanism is of much less significance in the this species (MALCOLM, 1988).

Unlike the larval selection, adult selection with deltamethrin for 40 generations did not lead to any significant levels of deltamethrin resistance. However, similar adult selections performed by CHADWICK *et al.* (1984) on the BKK strain of *Ae. aegypti* with permethrin, raised the tolerance to an irregular plateau 7 to 10 times the original. This finding is of significance as it implies that controlled usage of deltamethrin as an adulticide in the fields against *Cx. quinquefasciatus* would not induce high resistance levels in the adults. It can also be concluded that even though high larval resistance develops upon intense laboratory selection, the addition of PBO can drastically reduce the speed of development of deltamethrin resistance in this mosquito.

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OVIPOSITIONAL RESPONSE OF *BOMBYX MORI* L TO DIFFERENT TEXTURES OF THE SUBSTRATUM

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The influence of the texture of the substratum on the egg laying behaviour of the silkworm *Bombyx mori* L was examined using six different types of substrata. It was observed that the texture of the substratum markedly influences oviposition in terms of the number of eggs laid, total time taken for complete egg laying and the rate of egg laying.

It was also evident that the moth receives information about the texture of the substratum through the sensory hairs present on the anal papillae.

INTRODUCTION

Insects are known to exhibit strong preferences for specific substrata for oviposition (DOANE, 1967; PEDIGO, 1971; VAN DEN BOS & BALTENSWEILER, 1977). In majority of the instances these preferences for oviposition sites are of great survival value. To achieve this, insects are known to depend on olfactory, mechanical, thigmotactic or other stimuli received through sensory structures present on various parts especially the antennae, palps, tarsi and often the ovipositor itself (BARTON-Browne, 1960; VAN DEN BOS & BALTENSWEILER, 1977).

The silkmoth *Bombyx mori* L differs from other insects in its behaviour in several respects which may be partly due to the fact that it has been domesticated long ago. Traditional practices have been evolved over generations either because they are cost effective or convenient, while some because they have proved beneficial. Therefore, not all methods used in the maintenance of silkworms have been evolved scientifically and proved optimal. The general practice in India is to provide a smooth brown paper as the substratum for the moths to oviposit.

It is therefore, interesting to study the effects of different types of substrata on oviposition behaviour of silkworms.

Silkmoth is known to lay eggs in a compact group with eggs packed one next to the other but never one above the other (YAMA-OKA *et al.*, 1971; GEETHABALI *et al.*, 1984). The present work was carried out to see how the moth behaves when different types of substrata are provided and to see whether and how various aspects of oviposition behaviour are affected as a result of the differences in the substrata provided.

Secondly our present knowledge on the sensory structures in silkworm is highly limited. There have been only a few studies giving information about the antennae and certain mechano-sensory hairs (SCHNEIDER, 1975).

Earlier studies of YAMAOKA *et al.* (1971) have shown that the sensory hairs on the ovipositor of the silkmoth influence oviposition. It was suggested that the sensory input received by these hairs on the anal papillae are involved in triggering oviposition. However, there have not been any studies carried

out so far to show whether the hairs on the ovipositor are capable of perceiving sensory information about the texture of the substratum. The present study was aimed at understanding the role of sensory hairs on the ovipositor more precisely.

MATERIAL AND METHODS

Female silkmoths (*Bombyx mori* L 'NB7') of bivoltine race were used for all the experiments.

The female silkmoths after their emergence from the cocoons were allowed to mate for 4 to 5 hours after which they were left for egg laying on different substrata. The types of substrata provided were: (1) plain brown paper with dry surface; (2) plain paper with wet surface – a plain brown paper was placed on a filter paper. One end of the filter paper was kept in contact with sponge soaked in water; (3) Paper with ridges and grooves: thin broom sticks of uniform diameter were stuck to a plain brown paper maintaining a uniform distance of 1 mm in between; (4) sand papers of different sized grains (large – 0.79 mm, medium – 0.42 mm, small – 0.17 mm).

The hairs on the ovipositor were carefully removed under a dissection microscope and the cut ends treated with conc. hydrochloric acid to kill the underlying dendrite. This required 60–70 minutes for each animal. Such animals devoid of hairs on the ovipositor were allowed to copulate for 4 to 5 hours and left on different substrata and their egg laying behaviour was observed for 3 days after which most of the moths died or laid negligible number of eggs. For this purpose large groups of 30 moths were used for each experiment in order to overcome the differences due to individual variations.

RESULTS AND DISCUSSION

It was evident that the percentage of oviposition was high on smooth plain paper compared to all other surfaces provided. In case of wet smooth surface, the moths laid only 53% of the eggs compared to the dry smooth surface (Fig.1) and the eggs were laid in clumps and were not attached to the substratum unlike in the case of other substrata. When substrata with different sized sand grains were provided, the percentage of oviposition decreased with increase in the size of the sand grains. The moths laid about 33% of the eggs on large sized grains (0.73 mm), about 48% on the medium sized grains (0.42 mm) and about 70% on the small sized grains (0.17 mm) (Fig. 2). When substratum with ridges and grooves were provided, the percentage of oviposition was 69% (Fig. 3) and the eggs were laid only in the grooves.

When the moths without hairs on the ovipositor were provided with dry smooth surface, the number of eggs laid was reduced to 47% of the normal moths under similar conditions. It was observed that these moths laid nearly as many eggs on all the types of sand papers as normal moths (Fig. 4). On the substratum with ridges and grooves, the moths without hairs laid eggs both on ridges and in the grooves. When the hairs were ablated only on one of the anal papillae, the moths were able to lay nearly as many eggs as the normal ones by bending its abdomen towards the other side keeping the anal papillae with sensory hairs intact in contact with the substratum. In such moths, the initiation of oviposition was delayed by 2 to 3 hours and the rate of egg laying was slow compared to that in the normal animals. The animal was repeatedly scanning the substratum and retracting its ovipositor inside, thus increasing the interval between laying of successive eggs.
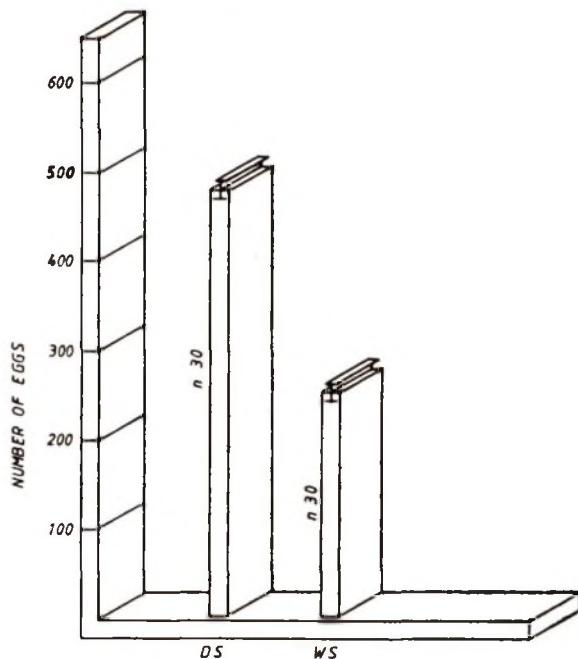
Fig. 1. Mean number of eggs laid ± SE on wet (WS) and dry surfaces (DS).
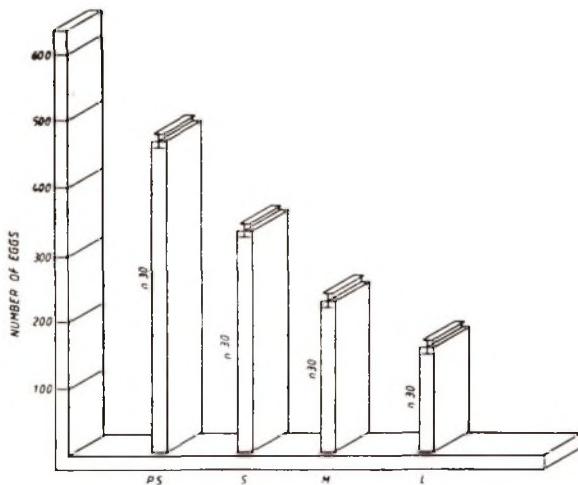
Fig. 2. Mean number of eggs laid ± SE on sand paper with different grain size.
PS-plain smooth surface; S-Small (0.17 mm) sand grains; M–medium (0.42 mm) sand
grains; L–large (0.73 mm) sand grains.

It is clear from the above results that the moth behaves differently on different types of substrata. The number of eggs laid was maximum on the smooth paper and decrea-sed with increase in the roughness of the substratum. The presence of moisture in the substratum also led to decrease in the number of eggs laid. In many insects, pre-
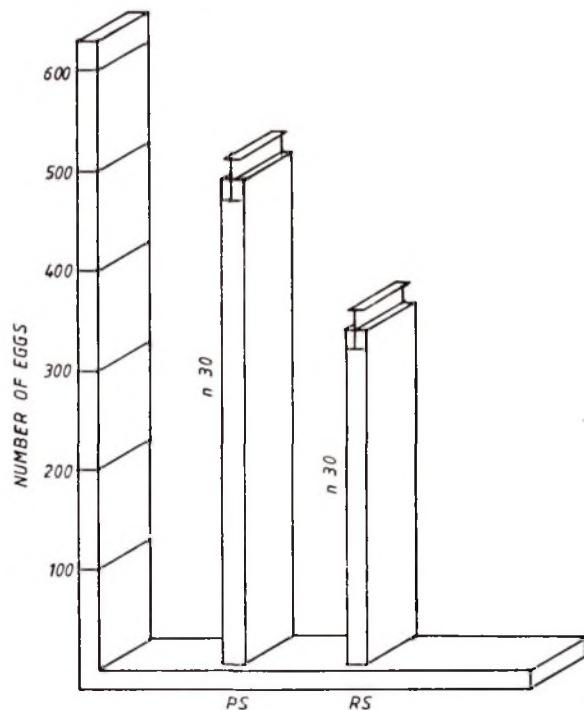
Fig. 3. Mean number of eggs laid ± SE on plain smooth surface (PS) and rough surface with
ridges and grooves (RS).
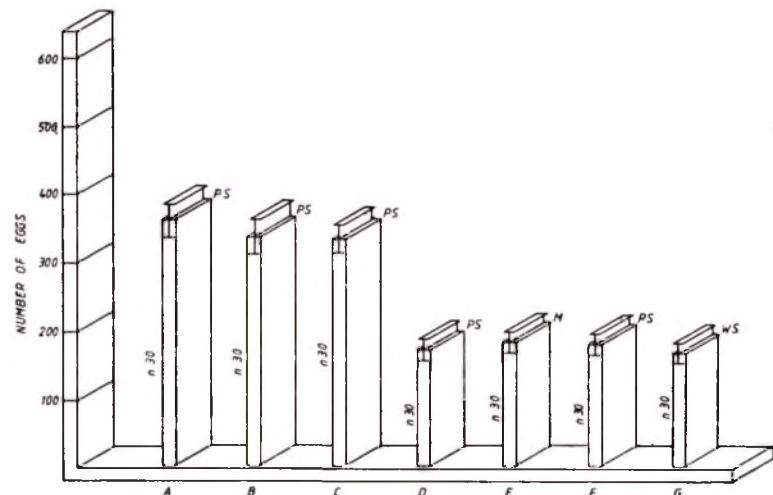
Fig. 4. Mean number of eggs laid ± SE by treated moths on different substrata.
A – Untreated moth; B – Hairs ablated on left side; C – Hairs ablated on right side; D – Hairs ablated on
both the sides; E – Ablated on sand paper (0.42 mm); F – Ablated on rough surface with ridges and grooves;
G – Ablated on wet surface; PS – Plain surface.

sence of moisture facilitates egg laying and this is survival value for the young ones emerging from the eggs (DOANE, 1966). It is also clear that when the sensory hairs on the ovipositor are removed, the moth fails to discriminate between various types of substrata. In such moths though the percentage of eggs laid is less compared to the normal untreated moths, the number of eggs laid is nearly the same on all the types of substrata. This shows that the sensory hairs on the ovipositor are mechanosensory and are capable of perceiving information about the texture of the substratum. It is also clear that these hairs not only provide the mechanosensory information but also are absolutely essential for the moth to get this information. Our observations on the morphology of these hairs also showed that they are long and have a sharp tip which are characteristic feature of mechanosensory hairs.

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SOME NEW OBSERVATIONS ON THE NEUROENDOCRINE SYSTEM IN DIPTERA

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Investigations on the neuroendocrine system of 20 dipteran species revealed the presence of 7–30 neurosecretory cells in the frontal ganglion of 10 species. In some cases the 'A' type median neurosecretory cells of the brain are unusually large. Neurosecretory cells have also been noted in the tritocerebral region of the brain as well as in the prothoracic ganglion. Both types of organisation of the retrocerebral endocrine organs viz., paired corpora cardiaca-corpora allata and a ring gland are noticed in sub-orders Nematocera and Brachycera. Only ring gland organisation is present in Cyclorrhapha.

The Diptera differ from other insects in respect of organisation of the neuroendocrine system (NES) in that the corpora cardiaca-corpora allata may get transformed into a ring gland (Weismann's ring) around the aorta, at a relatively posterior position, the ventral glandular structure being the corpus cardiacum (CC) and the dorsal glandular enlargement being the corpus allatum (CA) (WIGGLESWORTH, 1972). However, paired CC–CA are also known in some dipterans (LEA, 1963). RICHARDS & DAVIES (1977) are of the view that the organisation of the NES in the Diptera is related to the taxonomy of the order so that insects belonging to the sub-order Nematocera have paired CC–CA, while those belonging to the sub-order Cyclorrhapha always have a ring gland. Insects belonging to the sub-order Brachycera are stated to have "somewhat intermediate" arrangement. However, this "somewhat intermediate" arrangement has not been elaborated by the above authors.

Earlier investigations have revealed the presence of neurosecretory cells (NSC) in the

frontal ganglion (FG) in some insects (BORG et al., 1973; BELL et al., 1974; CHIH MING-YI & CHIPPENDALE, 1975; PATHAK & MUKERJI, 1984). The occurrence of these NSC in the FG has not so far been reported in any dipteran species.

Since the total number of dipteran insects in which NES has been studied so far is far too small (PATHAK, 1986), it was decided to undertake this study in a large number of dipterans belonging to all the three sub-orders.

The NES of 20 dipteran species (Table 1) was studied, using paraldehyde fuchsin (EWEN, 1962), chrome alum haematoxyline phloxine (GOMORI, 1941) and trioxyhaematin (PANTIN, 1960). The results revealed a number of interesting features.

Of the 20 insects studied, NSC were present in the frontal ganglion in 10 species (Table 2, Fig. 1). Of these 10, one belonged to the sub-order Nematocera, 5 to the sub-order Brachycera and 4 to the sub-order Cyclorrhapha. All NSC of the FG are of the same type and stain deep purple with paraldehyde fuchsin. Their number varies from 7–30 in

TABLE 1. Organisation of the CC–CA complex in the 20 dipteran species studied.

S. no.	Species	Family	Sub-order	CC–CA organisation
1.	*Mansonia dives* Schiner	Culicidae	Nematocera	Paired CC–CA
2.	*Pachyrhina bombeyensis* Macq.	Tipulidae	–do–	–do–
3.	*Plecia fulvicollis* F.	Bibionidae	–do–	–do–
4.	*Psychoda bengalensis* Bru.	Psychodidae	–do–	–do–
5.	*Dasyneura lini* Barnes	Cecidomyiidae	–do–	–do–
6.	*Chironomus rufipes* Linn.	Chironomidae	–do–	Ring gland
7.	*Tanypus varius* F.	–do–	–do–	–do–
8.	*Chrysops dispar* Fab.	Tabinidae	Brachycera	Paired CC–CA
9.	*Tabanus speciosus* Ricardo	–do–	–do–	–do–
10.	*Sargus metallinus* F.	Stratioyidae	–do–	–do–
11.	*Philonicus albiceps* Meig.	Asilidae	–do–	Ring gland
12.	*Solva* sp.	Solvidae	–do–	–do–
13.	*Dolichopus atratus* Meig.	Dolichopidae	–do–	–do–
14.	*Eristalis taphicus* Wied.	Syrphidae	Cyclorrhapha	–do–
15.	*Iscriodon scutellaris* Fabr.	–do–	–do–	–do–
16.	*Stomorhina xanthogaster* Wied.	Calliphoridae	–do–	–do–
17.	*Chrysomya rufifacies* Macq.	–do–	–do–	–do–
18.	*Dichaetomyia luteiventris* Rondani	Muscidae	–do–	–do–
19.	*Dacus diversus* Coq.	Tephritidae	–do–	–do–
20.	*Lauxania aenia* Fall	Lauxanidae	–do–	–do–

TABLE 2. Dipterans included in the present study, having neurosecretory cells in the frontal ganglion.

S. no.	Species	Number of NSC in the FG	Average diameter (in μm) of NSC of the FG
1.	*Plecia fulvicolils* F.	20	5
2.	*Chrysops dispar* Fab.	8 – 10	2.5
3.	*Sargus metallinus* F.	7 – 8	3
4.	*Philonicus albiceps* Meig.	24 – 26	2.5
5.	*Solva* sp.	10 – 15	2
6.	*Dolichopus atratus* Meig.	22	2
7.	*Eristalis taphicus* Wied.	7 – 8	2
8.	*Chrysomya rufifacies* Macq.	10 – 12	8
9.	*Dichaetomyia luteiventris* Rondani	25 – 30	2
10.	*Lauxania aenia* Fall	18 – 20	1.5

various species. These may be small (dia. 1.5 – 3.0 μm), medium (dia. 5.0 μm) or large (dia 8.0 μm). The neurosecretory material (NSM) from these NSC is seen to pass into the recurrent nerve.

A connection between the recurrent nerve and the CC had earlier been noted by TOM-BES (1972) in the beetle *Hypera punctata* and by PATHAK & MUKERJI (1984) in the cockroach *Supella supellectilium*. Such a connection has not been noticed in any of the dipterans studied here irrespective of the presence or absence of NSC in the FG.

The distribution, types, number and size of various NSC of the median and lateral groups of the pars intercerebralis of the protocerebrum follow the general pattern seen in most insects, except that the size of 'A' type NSC is unusually large in some cases (Fig. 2). Unlike hemipterans in which lateral group of NSC are either totally absent or have only 'B' type NSC (DOGRA, 1967; AWASTHI, 1972a), 'A' type NSC are present in the lateral group also, in addition to the median group, in all the 20 species studied. NSC have also been seen in the tritocerebral region in 8 species. While the neurosecretory path ways of the NSC of the median group are distinct and show the typical decussation (Fig. 3), those of the lateral and tritocerebral groups of NSC are indistinct.

In the suboesophageal ganglion, NSC are arranged usually in three groups – one posterior and two anterolateral. In *Dacus* however, these NSC are distributed randomly. NSC were also noticed in the prothoracic ganglion of *Eristalis taphicus* (Fig. 4).

The CC-CA complex does not appear to conform to the statement of RICHARDS & DAVIES (1977) because it is noticed here that both types of organisation i.e., the paired CC-CA as well as ring gland are represented in two out of the three sub-orders viz., Nema-

tocera and Brachycera. In Sub-order Cyclorrhapha, however, CC-CA are always in the form of a ring gland (Table 1, Fig. 5). In the Sub-order Nemotocera, 2 out of 7 species studied had ring gland while the other 5 had paired CC-CA. In Sub-order Brachycera, 3 species had a ring gland while the other 3 had paired CC-CA. In none of the 20 species, any organisation that could be described as "intermediate" or "somewhat intermediate" was noticed. In the light of these observations, the organisation of CC-CA does not appear to have any bearing on the taxonomy of the order.

Neural connection between the CC and the CA (NCA_1) was seen only in those cases which possess paired CC-CA. A nerve connection between the CA and the sub-oesophageal ganglion (NCA_2) was seen in one case viz., *Tabanus speciosus* (Fig. 6). Neural connections between the CA and aorta (NAA) and between the CA and the oesophagus (NAO), as described by AWASTHI (1972b) and PATHAK (1980), could not be seen in any case.

In insects having paired CC-CA, each gland has a separate sheath of its own but in *Dasyneura lini*, CC and CA of each side are covered by a continuous common double sheath.

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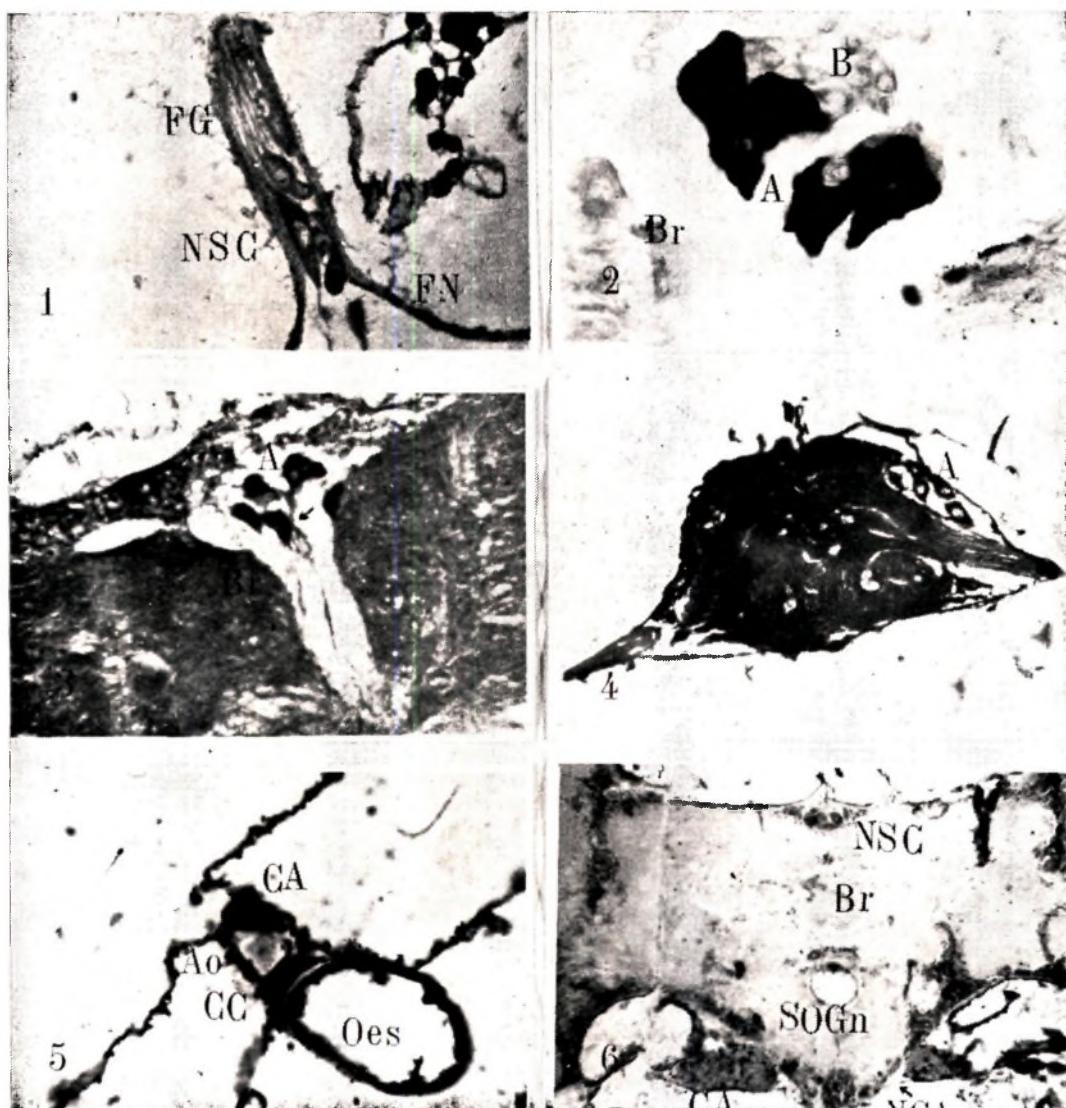
Fig. 1. Section of the frontal ganglion of *Chrysomya rufifacies* showing the NSC. PF.×400.   Fig. 2. H. L. S. Brain of *Tabanus speciosus* shownig very large 'A' type median NSC. PF.×400.   Fig. 3. H.L.S. Brain of *Dacus diversus* showing the median NSC.   The decussation of the axons of the left and right median NSC can be distinctly seen. PF.× 400.   Fig. 4. Section of the pothoracic ganglion of *Eristalis taphicus* showing deeply stained 'A' type NSC. PF.×100. Fig. 5. Section of *Lauxania aenia* showing the ring gland. PF.×400. Fig. 6. H.L.S. of the suboesophageal ganglion and retrocerebral endocrine organs of *Tabanus speciosus* showing the NCA₂.   PF.×100.

Abbreviations used

A – 'A' type neurosecretory cells; Ao – Aorta; B – 'B' type neurosecretory cells; Br – Brain; CA – Corpus allatum; CC – Corpus cardiacum; FG – Frontal ganglion; FN – Frontal nerve; NCA₂ – Nervi corporis allati 2; NSC – Neurosecretory cells; Oes - Oesophagus; SOGn – Suboesophageal ganglion.

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ON ORIENTAL SPECIES OF *MESOEURYTOMA* (EURYTOMIDAE), WITH NOTES ON TWO NEW SYNONYMS IN CHALCIDIDAE (HYMENOPTERA)

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Four new species viz. *Mesoeurytoma nigriscaposa*, *M. caudata*, *M. raoi* **from India and** *M. townesi* **from Malayasia, are described. A dichotomous key to Oriental species of** *Mesoeurytoma* **is provided. Two new synonyms in Chalcididae are alo proposed.**

(*Key words:* four new species, Eurytomidae, *Mesoeurytoma*)

In recent years we have collected several interesting material belonging to the chalcidoid family Eurytomidae, a family which is rather poorly represented in the Indian fauna.   In this paper four new species of the little known genus *Mesoeurytoma* Cameron (a new record for India) are described; three species from India and one from Malaysia.   A key for separation of the Oriental species of the genus is also provided.

We take this opportunity to comment on a genus and one species belonging to the family Chalcididae. These could not be dealt with in the recently published revision of Oriental Chalcididae (Narendran, 1989) as the papers were not available to that author at that time.

The abbreviations used in this paper are: AEI: American Entomological Institute, Gainesville, Florida, USA; DZCU : Department of Zoology, University of Calicut; m : Marginal vein;   OD :   Ocellar diameter (lateral); OOL : Ocellocular length; pm : Postmarginal vein ; POL : Postocellar length; st : Stigmal vein.

Genus MESOEURYTOMA Cameron

The genus *Mesoeurytoma* was errected by Cameron (1911) based on the type species *M. cariniceps* Cameron, collected in Borneo. Burks (1971) redefined the genus and confirmed Mr. Gahan's observation that *Stireurytoma* Cameron (1911) is a synonym of *Mesoeurytoma*. This generic synonymy was later published by Boucek (1988) who pointed out that though the two type species, *M. cariniceps* Cameron and *S. carinata* Cameron, are congeneric, the species are not *conspecific*. In our studies we have come across three species from India and one species from Malaysia which are new to science. These are described below.

1. Mesoeurytoma nigriscaposa sp. n.
(Figs. 1–3)

Holotype female : Length 3.1 mm. Black, apices of all femora, apex of mid-trochanter, bases and apices of all tibiae brownish yellow; forewing veins and all tarsi testaceous; pubescence brownish.

Head densely and umbilicately punctured except in malar space; relative measurements : head dorsal, length: width, 54 : 100;
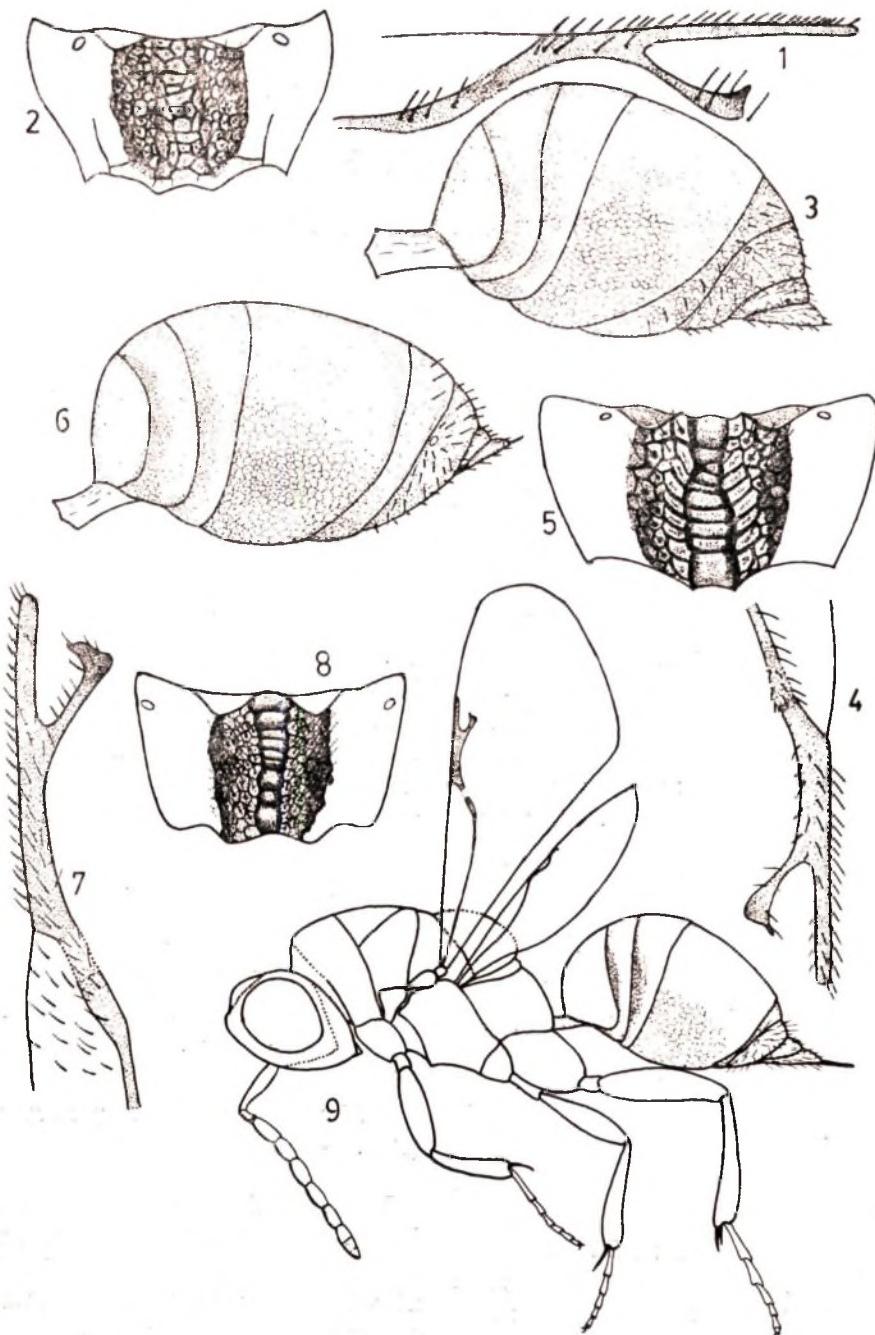
Figs. 1–3. *Mesoeurytoma nigriscaposa* sp.n.: 1, Venation; 2, Propodeum; 3, Gaster.
Figs. 4–6. *M. raoi* sp.n. :   4, Venation;   5, Propodeum   6, Gaster.
Figs. 7–9. *M. caudata* sp.n. :   7, Venation;   8, Propodeum;   9, Habitus,

maximum width of head : maximum height (excluding mandibles). 100 : 70; median; strip on lower face (between antennal toruli and mouth margin) slightly raised and bordered by two strong carinae with small vertical wavy carinae in between; on lower face punctures distinct, a few punctures on either side of mouth margin confluent into shallow channels radiating from corners of mouth margin. Frons concave, parascrobal space bordered by raised preorbital carinae. Scrobe deep, its margins carinate; front ocellus located in a smooth area just above dorsal margin of scrobe, this area encircled by carinae; preorbital carinae very distinct, dorsally these extend as transverse carinae running between front and lateral ocelli; postorbital carinae distinct only on ventral parts of eyes, become obsolete dorsally. Relative measurement of POL : OOL : OD – 100 : 61 : 38; malar groove absent, malar shagreened; gena posteriorly carinate, edge of this carina shagreened. Eye length : width – 100 : 87, eye length : malar space – 100 : 52 (lateral view). Antenna 11153; scape reaching front ocellus; first funicular segment longest, second to fourth subequal, fifth shortest; club three segmented (first one distinct, second and third fused).

Thorax densely and umbilicately punctured, punctures deep, interstices narrow, microsculptured; relative measurements – length : width (mesoscutum): height – 100 : 60 : 60; anterior margin of pronotum carinate, this carina weakly interrupted on meson so as to form two vague median teeth; its posterior margin concave; collum shagreened. Tegula aciculated on hind-margin. Mesopleuron with mesepimeron having two incomplete rows of piliferous punctures on its posterior margin, rest minutely reticulate; mesepisternum rugulose with horizontal striation; epicnemial area slightly raised and with a row or piliferous punctures; mesosternal shelf umbilicately punctured,

its height subequal to height of forecoxal depression; subalar area smooth and shiny; propodeum slightly sloping, its median area deeply concave with sculpturing as in Fig. 2. Forewing 2.3 × as long as broad m : pm : st – 46 : 100 : 54 (Fig. 1).

Gaster (Fig. 3) petiolate; m length of petiole : width – 100 : 66; relative measurement of length of gastral body : breadth : height – 100 : 42 : 60; fourth gastral tergum dorsally the longest; sculpturing on terga as in Fig. 3.

Male: Length 2.3 mm. Legs and antennae darker than those of female. Essentially similar to female except in having the antennae plumose and gastral body small with a relatively long (longer than hind–coxa) petiole.

Host : Unknown.

Holotype: INDIA: Kerala, Silent Valley, 9 xii.1987, **T.C. Narendran and party, (DZCU); Paratype:** 1 ♂, same data as for holotype.

Remarks : This species can be easily distinguished from other species by its short marginal and very long postmarginal veins.

2. **Mesoeurytoma raoi** sp. n. (Figs. 4–6)

Holotype female : Length 3.5 mm. Black; scape, first two funicular segments, forefemur except mid-ventral region, mid-femur, base and apex of hind-femur, fore -: mid - and hind-tibiae and fore-tarsi brown; pedicel, last three funicular segments, club, midventral region of fore-femur, middle region of hind-femur, all trochanters and mandibles blackish brown; mid- and hind-tibiae and forewing veins testaceous. Wings hyaline; pubescence pale brown. Other characters essentially similar to *M. nigriscaposa* except the following:

1. Relative measurements:

Head (in dorsal aspect) length : width – 53 : 100; anterior height : width – 75 : 100; lateral height : width – 100 : 71. Eye (in profile) length : width – 100 : 85; eye length : malar space – 100 : 41. POL : OOL : OD – 100 : 59 : 41. Thorax length : width (mesoscutum) : height – 100 : 69 : 71. Forewing length : width – 100 : 42; m : pm : st – 100 : 96 : 60. Gaster length (excluding petiole and ovipositor) : width : height – 100 : 36 : 54. Propodeum with its median areas as in Fig. 5. Gaster with microsculpuring on terga as in Fig. 6.

Male : Unknown

Host : Unknown

Holotype: ♀, INDIA, Kerala, Calicut University Campus, July 1986, T. C. Narendran & Party (DZCU).

Remarks : This species resembles *M. caudata* sp. n. in general features but differs from it in colouration, sculpturing of propodeum and in having relatively short and uniformly broad marginal vein. This species is named after Dr. B. R. Subba Rao, formerly of CAB International Institute of Entomology, London, for his significant contributions to the study of Indian Eurytomidae.

3. Mesoeurytoma caudata sp. n. (Figs. 7–9)

Holotype female : Length 3.9 mm. Black; scape except apex, apices of fore-, mid- and hind-femora, anterior margin of fore-tibia, fore-tarsi, apex and base of mid-tibia, hind-tibia, forewing vein and ovipositor brown; mid- and hind-tarsi yellow, all trochanters, apex of ovipositor sheath, antenna axecept scape and pedicel brownish black; apex of scape, pedicel and mandibles blackish brown; Wings hyaline; pubescence pale brown.

Other characters essentially similar to *M. nigriscaposa* sp. n. except the following:

Relative measurements:

Head (in dorsal aspect) length : width – 55 : 100; in anterior aspect height : width – 70 : 100; in profile height : width – 100 : 63. Eye (in profile) length : width – 100 : 83 ; eye length : malar space – 100 : 50. POL : OOL : OD – 100 : 68 : 43. Thorax length : width (mesoscutum) : height – 100 : 63 : 73. Forewing length : width – 100 : 42 ; m : pm : st – 100 : 65 : 48. Gaster length : width : height – 100 : 35 : 53. Propodeum with its median area as in Fig. 8. Gaster with microsculpuring on terga as in Fig. 9.

Male : Unknown.

Host : Unknown.

Holotype: ♀, INDIA : Kerala, Parambikulam, 14. xii. 1985, T. C. Narendran & Party (DZCU).

Remarks : This species closely resembles *M. raoi* sp. n. but differs from it in colouration, sculpturing of median area of propodeum and in having a comparatively long and medially narrowed marginal vein.

4. Mesoeurytoma townesi sp. n. (Figs. 10–14)

Holotype female : Length 3.9 mm. Black; antenna except scape and anellus, mandibles, all trochanters, apex of ovipositor sheath, middle region of mid-femur backish brown; scape, anellus, apices and bases of fore-,mid- and hind-femora, hind-tibia and forewing vein pale brown; fore- and hind-femora except bases and apices and mid-coxa brownish black; fore- and mid-tibiae and fore-tarsus testaceous; mid- and hind-tarsi pale yellow. Wings hyaline; pubescence pale brown.

Other characters essentially similar to *M. nigriscaposa* sp. n. except the following:
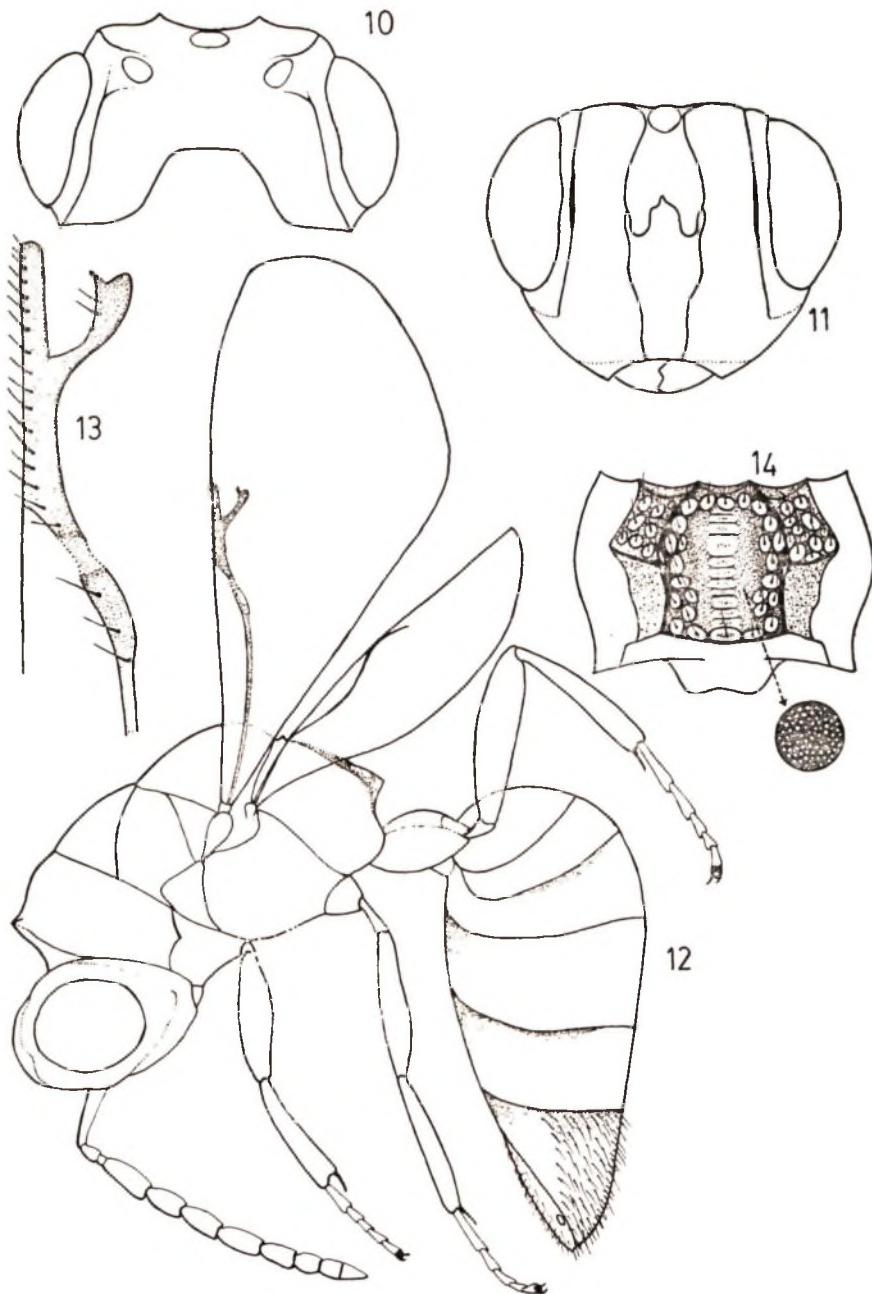
Figs. 10–14. *M. townesi* sp.n. : 10. Head dorsal view; 11. Head anterior view; 12. Habitus; 13. Venation; 14. Propodeum.

Head (in dorsal aspect) length : width – 57 : 100 ; in anterior aspect height : width – 77 : 100 ; in profile height : width – 100 : 82; eye length : malar space – 100 : 50. POL : OOL : OD – 100 : 30 : 30. Thorax length : width (mesoscutum) : height – 100 : 55 : 60. Forewing length : width – 100 : 43 ; m: pm : st – 100 :76 : 76. Gaster length : width : height – 100 : 30 : 44. Propodeum with its median area deeply concave, carinate on sides, carinae shagreened on their edges sculpturing as in Fig. 14; posterior part of propodeum steep (about 85° to the median area), smooth with a median depression, petiole attached lower to this depression (Fig. 12). Gaster longer than thorax, gradually narrows towards apex; sixth tergum large and densely pilose (Fig. 12).

Male : Length 3.2 mm. Similar to female except the antennae plumose and gastral body small with a long petiole (petiole longer than hind-coxa).

Host: Unknown.

Holotype : ♀, MALAYSIA: Negri Sembilan, Pasoh Forest Reserve; P 3–v. 1978, P. & M. Backer, (AEI); **Paratype:** 1 ♂, same data as for holotype except date 6.xii.1978.

Remarks: This species differs from all other species in having long conical gaster longer than thorax with a large plumose epipygium, in having peculiar sculpturing on the median area of propodeum and in the shape of carinae bordering the median strip on lower face.

This species is named after the late Dr. Henry Townes of the American Entomological Institute, Gainsville, Florida, USA for his significant contributions to the study of parasitic Hymenoptera.

KEY TO ORIENTAL SPECIES OF
MESOEURYTOMA CAMERON

1. Second tergum of gaster distinctly longer than third; (gaster distinctly shorter than thorax, venation pale testaceous) .... *cariniceps* Cameron

— Second tergum of gaster shorter than or equal to third tergum 2

2. Marginal vein shorter than stigmal; postmarginal a little over 2× length ot marginal (Fig. 1).......................... *nigriscaposa* sp.n.

— Marginal vein longer than stigmal; other characters different 3

3. Marginal vein 3× length of stigmal; central depression of propodeum widely and transeversely striated; forewing veins pale testaceous .... *carinata* (Cameron)

— Marginal vein at most slightly longer than of stigmal; other characters partly or completely different 4

4. Marginal vein a triffle over 2× length of, stigmal medially narrowed (Fig. 7): .... *caudata* sp. n.

— Marginal vein less than 2× of stigmal 5

5. Marginal vein 1.6× of stigmal, uniformly broad; venation testaceous (Fig. 4) ....*raoi* sp,n.

— Marginal vein 1.3× of stigmal; venation brown .... *townesi* sp.n.

Notes on Chalcididae

Recently Shafee and Dutt (1986) errected a new tribe of Chalcididae, Lamoundellini based on the genus *Lamoundella* Shafee & Dutt with type species *L. aligarhensis* Shafee & Dutt. A loan request for the type specimen did not materialise. From the description and figures, however, it is clear that *Lamoundella* is nothing but the commonly distributed Oriental genus *Epitranus* Walker (1834) and Lamoundellini is Epitranini. Hence *Lamoundella* Shafee & Dutt is here placed in synonymy (syn.n.) with *Epitranus* Walker and Lamoundellini Shafee and Dutt in synonymy (syn. n.) with Epitranini. The

above synonymy is based on the study of one of us (T. C. N.) who recently revised the Oriental *Epitranus* (Narendran, 1989). Jinkun (1989) recently described *Tainania aceroscutellaris* Jinkun. One of us (T.C.N.) studied the descriptions and figures of this species and is convinced that *T. aceroscutellaris* Jinkun is a synonym (syn. n.) of *Antrocephalus lugubris* (Masi, 1932).

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MECHANOSENSORY REGULATION OF GANGLIONIC PROTEINS IN THE MOLE CRICKET, *GRYLLOTALPA AFRICANA*

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Cercal deafferentation produced a decrease in the levels of total proteins, sucrose soluble and sucrose insoluble protein fractions and an increase in the free amino acid levels of the terminal abdominal ganglion in the mole cricket, *Gryllotalpa*. The changes observed were irreversible following bilateral cercectomy while the unilateral cerecectomized animals showed a recovery tendency in the ganglionic protein and amino acid levels after 15 days of cercectomy.

INTRODUCTION

The cerci of crickets are paired abdominal appendages which contain mechanosensory hairs responsive to sound and wind stimuli (Edwards & Palka, 1974). Cercal deafferentation (cercectomy, in the house cricket, *Acheta domesticus* produced detectable physiological and morphological changes in the target interneurons in the terminal abdominal ganglion (Murphey, 1977; Meyer & Reddy, 1985; Meyer *et al.*, 1986). In order to understand the metabolic communication between mechanosensory neurons and their central targets, present study was focussed on the changes in total proteins, sucrose soluble and insoluble protein fractions, and amino acid levels in the terminal abdominal ganglion of the mole cricket, *Gryllotalpa* following cercectomy.

MATERIALS AND METHODS

Mole crickets collected locally from moist places in the fields, were maintained in the laboratory ($28 \pm 3°C$). The animals were fed with cabbage and potatoes. After accli-

mation to lab. conditions for 3–4 days, the animals were devided into three batches; the first batch served as controls and the second and third batches underwent unilateral and bilateral cercectomy respectively. Removal of cerci was done with fine forceps. The last abdominal ganglion along with the cercal nerves and a portion of connectives was used for the assay on 1, 3, 5, 10, 15 & 30 days of cercectomy. Protein content of the ganglia was estimated by the method of Lowry *et al.* (1951) and the free amino acid content, by the method of Moore & Stein (1954). Statistical analysis of the data was done following the methods given by Snedecor & Cochran (1967).

RESULTS AND DISCUSSION

The total protein level in the ganglia exhibited a decrease following unilateral and bilateral cercectomy (Tables 1 and 2). The decrease in protein level was continuous up to 15th day following both unilateral (31.4%) and bilateral (34.4%) cercectomy. Thereafter, the animals with no cerci showed a further decrease in total proteins (Table 2), while the animals with one cercus intact showed an increase towards control levels, exhibiting a recovery tendency (Table 1).

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TABLE 1.   Changes in protein (mg/g wet wt) and free amino acid (mg. tyrosine equivalents/ g wet wt) levels in the terminal abdominal ganglion of the cricket, *Gryllotalpa* following unilateral cerecectomy.

Post cercectomy time periods	Total proteins	Sucrose soluble proteins	Sucrose insolube protein	Free amino acid
Control	78.58 ±1.77	32.72 ±0.94	36.56 ±0.74	31.69 ±2.42
1 day	72.54 ±1.05	28.97 ±0.89	32.52 ±0.60	31.98* ±2.10
3 days	68.94 ±1.58	26.72 ±0.81	30.42 ±0.45	32.14* ±2.14
5 days	64.25 ±1.25	24.18 ±0.93	28.17 ±0.30	34.12* ±2.17
10 days	59.94 ±1.02	22.23 ±0.79	25.13 ±0.22	36.80 ±2.49
15 days	53.90 ±1.08	20.16 ±0.76	23.87 ±0.29	41.05 ±2.52
30 days	62.50 ±1.32	23.92 ±0.89	26.85 ±0.38	36.85 ±2.58

All the values are significant ($P<0.01-0.001$) except the values marked*.

Each value is a mean of four individual observations ±SD.

TABLE 2.   Changes in protein (mg/g wet wt) and free amino acid (mg tyrosine equivalents/ g wet wt) levels in the terminal abdominal ganglion of the cricket, *Gryllotalpa* following bilateral cercectomy.

Post cercectomy time periods	Total proteins	Sucrose soluble proteins	Sucrose insolube proteins	Free amino acids
Control	78.58 ±1.77	32.72 ±0.94	36.56 ±0.74	31.69 ±2.42
1 day	70.69 ±1.09	26.89 ±0.67	30.95 ±0.54	32.14* ±2.09
3 days	66.46 ±1.06	24.15 ±0.73	28.94 ±0.63	34.98* ±2.14
5 days	62.44 ±1.40	22.58 ±0.85	26.85 ±0.38	35.42* ±2.36
10 days	58.48 ±1.24	21.44 ±0.74	24.58 ±0.59	38.38 ±2.46
15 days	51.50 ±1.43	19.85 ±0.72	22.45 ±0.68	43.36 ±2.54
30 days	49.60 ±1.28	16.45 ±0.58	19.41 ±0.21	48.47 ±2.88

All the values are significant ($P<0.01-0.001$) except the values marked*.

Each value is a mean of four individual observations ± SD.

The sucrose soluble and insoluble protein fractions of the ganglia also showed a reversible decrease in the unilateral cercectomized animals while the bilateral cercectomy produced a continuous decrement up to 30 days of post cercectomy (Tables 1 and 2). The decrease in sucrose soluble and insoluble protein levels (34.7% and 38.3% respectively) was maximum by 15 days of post unilateral cercectomy, while the decrease was maximum by 30 days (47.6% and 49.7% respectively in sucrose soluble and insoluble proteins) in animals with both cerci removed (Table 2).

On the contrary, the free amino acid content increased following both unilateral and bilateral cercectomy (Tables 1 and 2) up to 15th day. Ablation of one cercus produced a continuous increase (29.4%) in amino acid content up to 15 days after cercectomy and thereafter showed a drop toward control levels (Table 1). The bilateral cercectomy produced irreversible increase in amino acid content through 30 days with a maximum increase of 52.9% (Table 2).

A decrease in protein metabolism following cercectomy has hitherto been reported only for the house cricket, *Acheta domesticus* (EDWARDS & MEYER, 1985). The giant interneurons in the terminal ganglion of the cricket respond to deafferentation with diminished growth of their primary dendrites (MURPHEY & LEVINE, 1980). Decreased soluble protein in the antennal lobes of deafferented brains have been reported for the moth, *Manduca sexta* (SANES *et al.*, 1977). The decrease in sucrose soluble and insoluble protein fractions might be due to induction of proteolytic activity following cercectomy. Degenerative changes in the cercal sensory nerve and the sensory neuropile in the ganglion were observed in the deafferented terminal ganglion of the cricket, *Gryllotalpa* (HIMASAILA-KUMARI, 1988). The observed decrease in protein levels might be due to degeneration of sensory axons and their synaptic terminals in the ganglia. Since the unilateral cercectomized animals have one normal cercus, the decrease in proteins was less, and showed a recovery after 15 days at which time the cercus develops compensatory mechanisms through dendritic sprouting (VERDI & CAMHI, 1982).

The changes in amino acid level appeared to correlate with duration of deafferentation. The decrease in protein levels in deafferented ganglia of *Gryllotalpa* might have contributed to a rise in free amino acid pool. The increase in amino acid level may also be due to increased amino acid synthesis. Cercal deafferentation clearly showed a striking effect on the free amino acid level of the ganglion, and this was not an injury response as observed in most axotomized neurons (WATSON, 1974).

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IMPORTANCE OF OVARIOLE NUMBER IN COCCINELLIDAE (COLEOPTERA)

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A list of ovariole number in **58 species** belonging to **26 genera** of six sub-families of family Coccinellidae is presented.   It ranges from **7 per ovary** in the members of the genus *Cryptogonus* of Scymninae to **62** in *Coccinella septempunctata* Linnaeus of Coccinellinae.   This number is interpreted from the view point of taxonomy, evolution and fecundity.   It is suggested that ovariole number can be used as a taxonomic character.   Also inferred is that multiplication, reduction and stabilization of ovariole number have occurred in evolution of occinellids.

(*Key words*: Coccinellidae, taxonomy, ovarioles, stabilization)

INTRODUCTION

DOBZHANSKY (1924, 1926) described the reproductive system of 53 species of Coccinellidae from Russia and pointed out intraspecific variation of ovariole number in many species.   KURISAKI (1926) came of next to describe reproductive system of two species of Coccinellidae, but didn't mention the ovariable number.   The reproductive system of three more species of genus *Epilachna* was described by EHARA (1952), while in 1953, he only dealt with the comparative study of spermatheca in some local populations of two spp. of the same.   KATAKURA's (1981) work only deals with the sperm storage place in the females of the lady beetles but ANDERSON (1981), reported the intraspecific variation of ovariole in *Scymnodes lividigaster* (Mulsant), an Australian lady beetle.

Other important work on the internal genitalia of Coccinellidae has mostly been carried out as a part of the comparative survey of single organ system in Coleoptera.   For example, ROBERTSON (1960) described the ovarioles as a meristic character in Coleoptera and in 1961, he recorded the ovariole number of 329 species in 45 families of Coleoptera including Coccinellidae.   SUZUKI (1974) gave the taxonomic significance of ovariole number in 178 species of Chrysomelidae.   It is felt that the ovariole number is easily determined attribute and so, it was decided to assess its value in large number of species of Coccinellidae as has been done in some other groups of insects.   The present communication deals with 58 species belonging to 26 genera of 6 sub-families of Coccinellidae.

MATERIALS AND METHODS

The specimens examined were collected in various localities of India by the authors. The specimens were narcotized with ethyl acetate and the dissections for the reproductive systems were made in the field with the help of field dissection binocular stereoscopic microscope in 7% saline water.   A minimum of five specimens of each species were dissected to see the intraspecific variations. Some specimens were preserved in the mixture of alcohol and glycerine in the ratio of

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4:1 and then ovarioles which were held toge-
ther by connective tissue and tracheae were
separated and counted.   The identification
of the species worked out in the present study
were got confirmed from Commonwealth
Institute of Entomology, London.

RESULTS AND DISCUSSION

The ovarioles per ovary in the members of
Coccinellidae are listed in Table 1.

The data reveals that some species have
constant number of ovarioles and this char-

TABLE 1.   Ovariole number per ovary in Coccinellidae.

Name of species	Ovarioles per ovary	Range
COCCINELLINAE		
Harmonia eucharis (Mulsant)	24—82	25.7 ± 2.06
Harmonia sedecimnotata (Fabricius)	27—32	29.1 ± 2.21
Harmonia dimidiata (Mulsant)	25—30	27.2 ± 2.21
Oenopia sexareata (Mulsant)	12	—
Oenopia billieti (Mulsant)	12	—
Oenopia kirbyi (Mulsant)	12	—
Calvia pinaki Kapur	9	—
Calvia shiva Kapur	14—18	16 ± 1.63
Calvia albida Bielawaski	9—12	11.2 ± 2.21
Calvia trilochana Kapur	11	—
Calvia pasupati Kapur	11	—
Calvia species E4	12—14	13.7 ± 1.70
Halyzia sanscrita Mulsant	19—22	20.3 ± 1.50
Halyzia straminae (Hope)	28—32	30.5 ± 1.91
Micrapsis allardi (Mulsant)	14	—
Micraspis cardoni (Weise)	10	—
Adalia luteopicta Mulsant	22—26	24.5 ± 1.91
Adalia tetraspilota (Hope)	17—24	20.7 ± 2.98
Lemnia duvaucelii Mulsant	18—22	20 ± 1.63
Lemnia bissellata (Mulsant)	13—18	15.2 ± 2.21
Alloneda dodecaspilota (Hope)	16—22	19 ± 2.58
Aiolocaria hexaspilota (Hope)	44—48	45.5 ± 1.91
Hippodamia variegata (Goeze)	21—24	22.2 ± 1.25
Menochilus sexmaculatus (Fabricius)	20—26	22.7 ± 2.75
Callicaria superba (Mulsant)	26—30	28 ± 1.63
Paleoneda miniata (Hope)	42—44	43.3 ± 1.15
Megalocaria dilatata (Fabricius)	20—26	23 ± 2.58
Illeis cincta (Fabricius)	19—22	21.7 ± 2.06
Pania luteopustulata (Mulsant)	12—16	13.5 ± 1.91
Coccinella septempunctata Linnaeus	54—62	58 ± 3.65

EPILACHNINAE

Henosepilachna vigintioctomaculata (Motschulsky)	24—28	26 $\pm$ 1.63
H. vigintioctopunctata (Fabricius)	28—36	34 $\pm$ 4.32
H. indica (Mulsant)	22—27	25.2 $\pm$ 2.21
H. dodecastigma (Wiedemann)	28—30	29.5 $\pm$ 1
H. ocellata (Redtenbacher)	29—32	30.7 $\pm$ 1.5
H. sp. C_{18}	17	—
H. processa (Weise)	27—29	27.5 $\pm$ 1
Epilachna marginicollis (Hope)	16—18	17.5 $\pm$ 1
Epilachna mystica Mulsant	22—26	23.5 $\pm$ 1.91
Epilachna dumerili (Mulsant	12—16	13.5 $\pm$ 1.91
Afidenta mimetica (Dieke)	20—24	21 $\pm$ 2
Afissula rana Kapur	13	—
Afissula sanscrita (Crotch)	9	—

CHILOCORINAE

Chilocorus rubidus Mulsant	36—40	37.5 $\pm$ 1.91
Chilocorus breiti Weise	9—12	10 $\pm$ 1.41
Chilocorus bijugus Mulsant	20—24	22 $\pm$ 1.63
Chilocorus nigritus (Fabricius)	9	—
Chilocorus hauseri Weise	15—20	17.2 $\pm$ 2.21
Chilocorus species B_{14}	16—20	17 $\pm$ 2.58
Chilocorus species K_6	12—16	13.5 $\pm$ 1.91
Exochomus uropygialis Mulsant	12	—

SCYMNINAE

Cryptogonus ariasi (Mulsant)	7	—
C. quadriguttatus (Weise)	7	—
C. orbiculus (Gyllenhal)	7	—
C. postmedialis Kapur	7	—

COCCIDULINAE

Rodolia guerini (Crotch)	20	—
Rodolia species G_{10}	12	—

STICHOLOTIDINAE

Jauravia quadrinotata Kapur	9	—

acter in each species has been suggested by SUZUKI (1974) as subject primarily to their phylogenetic or genetic background. He further interpreted that phylogenetically controlled ovariole number is known as basic number of ovarioles (BNO). On the other hand, the species exhibiting variations in ovariole number to various degree and these variations are probably influenced by various environmental conditions, especially, nutrition which probably affected the body size in the course of ontogeny.

Intraspecific variations in ovarioles:

It is apparent from Table 1 that intraspecific variation of ovariole number in Coccinellidae is a common factor and the same has not been properly studied except DOBZHANSKY (1926),who did report the intraspecific-variations in some species. SINGH *et al.* (1979) studied the reproductive system of *Coccinella septempunctata* Linnaeus (Fig. 1) but failed to observe any intraspecific variation of ovarioles, whereas DOBZHANSKY (1926) reported 61 ovarioles per ovary, but the present study revealed it exhibiting considerable intraspecific variability ranging from 54—62 (58±3.65). Among the other species having an especially high range of variations are; *Henosepilachna vigintioctopunctata* Fabricius (Fig. 2), 28—36 (34±4.32), *H. indica* Mulsant, 22—27 (25.2±2.21) of Epilachniae; *Adalia tetraspilota* (Hope) 17—24 (20.7±2.98), *Alloneda dodecaspilota* (Hope) 16—22 (19±2.58), *Menochilus sexmaculatus* (Fabricius) 20—26 (22.7±2.75), *Megalocaria dilatata* (Fab.) 20—26 (23±2.58) of Coccinellinae; *Chilocorus rubidus* Mulsant 36—40 (37.5±1.91) (Fig. 3), *C. hauseri* Weise 15—20 (17.2±2.21) of Chilocorinae. It has been observed that all the above mentioned species of high variability have high basic number of ovarioles (BNO). The authors are of the opinion that these variations must have exclusively

resulted from body size variations of the insects. In other species of small body size variation, the intraspecific variations of ovarioles are found to be of less extent. In other words, it can be said that more the basic number of ovarioles more the degree of variability and less the stability of the individual. The ovariole number in some of the species of Coccinellidae have been found to be constant and the species are considered to be more stable. It is 7 in the species of the genus *Cryptogonus* of Scymniae. However, Anderson (1981) reported the intraspecific variation of ovariole number i.e., 7–13 in *Scymnodes lividigaster* (Mulsant), an Australian lady bird; 9 in *Jauravia quadrinotata* Kapur of Sticholotidinae, *Chilocorus nigritus* (Fab.) of Chilocornae, *Afissula sanscrita* Crotch of Epilachninae and *Calvia pinaki* Kapur of Coccinellinae; 11 in *Calvia trilochana* Kapur and *C. pasupati* Kapur; 12 in the genus *Oenopia* of Coccinellinae and *Rodolia* sp. G_{10} of Coccidulinae and *Exochomus utopygialia* Mulsant of Chilocorinae; 14 in *Micraspis allardi* (Mulsant); 17 in *Henosepilachna* sp. C_{18} of Epilachninae and 20 in *Rodolia querini* (Crotch). These observations show that the ovariole number is stable in the species having few ovarioles essentially or low basic number of overioles (BNO). In the species having relatively large BNO, it is generally apt to vary in the way observed in a great number of species. SUZUKI (1974) has also reported asymmetrical ovariole number in some species of the Chrysomelidae; however, the present authors have not been able to find any such case in the present work.

Interspecific variation in ovariole number:

The members of the genus *Cryptogonus* (Fig. 4) of Scymniae have 7 ovarioles per ovary and do not show intraspecific variation. On the other hand, *Micraspis allardi*(Mulsant) belonging to Coccinellinae has 14 ovarioles
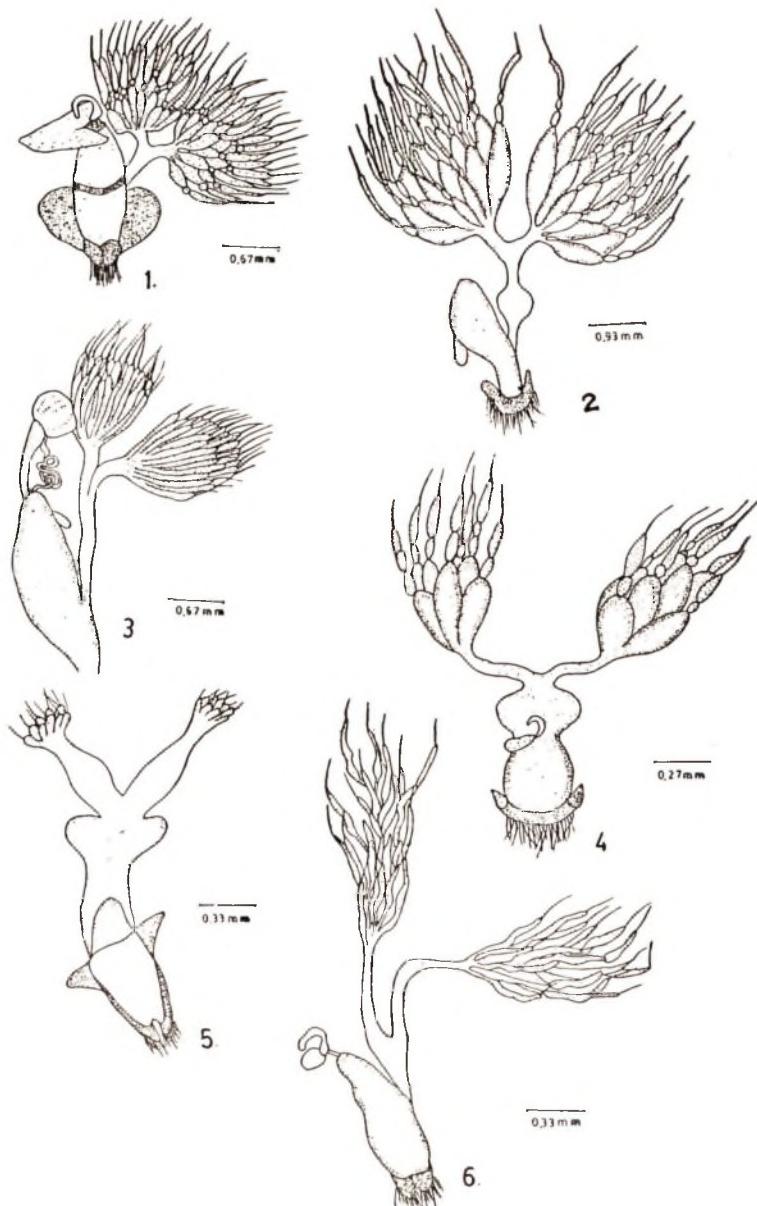
Figs. 1 to 6 showing female reproductive system in some coccinellids.
1. *Coccinella septempunctata*; 2. *Hensoepilaehna dodecastigma*; 3. *Chilocorus rubidus*; 4. *Cryptogonus orbiculus*; 5. *Afissula sanscrita*; 6. *Hippodamia variegata.*

per ovary. The size of the body of the latter is almost double the size of the former. The authors further think that the fact has proɔably to do with the differences in their life forms especially in immature stages and size and shape of the body of adults. According to ROBERTSON (1961), Coccinellinae and Epilachninae averages 16 and 17 respectively; within Coccinellinae the Hyperaspini, Scymini, Psylloborini and Coccinellini have values of 7, 6, 13 and 21 in that order. While present study reveals that BNO of the genus *Oenopia* and *Rodolia* sp. G_{10} is 12, it is 11 in *Calvia trilochana* and *C. pasupati,* 10 in *Micraspis cardoni* Weise, 9 in *Afissula sanscrita* (Crotch) (Fig. 5) of Epilachninae, *Chilocorus nigritus* of Chilocorinae and *Jauravia quadrinotata* of Sticholotidinae, 7 in the members of the genus *Cryptogonus* of Scymniae. The members of the genus *Cryptogonus* have almost same size and shape of the body, hence, they have equal number of ovarioles. The *Calvia pinaki* of Coccinellinae is of the size of *Afissula sanscrita* of Epilachniae and *Jauravia quadrinotata* of Sticholotidinae and they also have the same number of ovarioles.

In family Coccinellidae, the number of ovarioles is widely distributed ranging from 7 in the members of genus *Cryptogonus* of Scymniae to 62 in *Coccinella septempunctata* of Coccinellinae as shown in Table 1. The members of the family are variable in body size and body organization (or body forms) as has also been stated by SUZUKI (1974). In this group also, the ovariole number is influenced especially by the above mentioned two factors, in other words the small species cannot physically put many ovarioles in their body cavities and flat species also cannot keep many ovarioles for the same reason. As already mentioned that the body size of the *Calvia pinaki* of Coccinellinae, *Afissula sanscrita* (Fig. 5) of Epilachninae and *Jauravia quadrinotata* of Sticholotidinae

have almost the same body size and hence the same number of ovarioles i.e., 9. Authors are of the opinion that number of ovarioles are directly linked to the size of the body of an insect. However, some exceptions are there, e.g., *Aiolocaria hexaspilota* (Hope) and *Megalocaria dilatata* (Fab.) have less number of ovarioles i.e., 44–48 and 20–26 respectively as compared to *Coccinella septempunctata* (54–62) in spite of their large body size. In the cases like this, it is suggested that form and size of other internal organs especially the alimentary canal whose large size dominates the body cavity, is also connected with the determination of ovariole number. A species with small body size may have large and complex alimentary canal leaving little body space for ovarioles. Thus, co-evolution of the reproductive and digestive systems will have had a determining effect on the ovariole number.

The relationship of ovariole number to egg production is obscure in Coccinellidae. It is tempting to suppose that 124 ovarioles in both ovaries of the *Coccinella septempunctata* reflects a high fecundity which in turn, is related to high larval mortality. resulting from their uncertainty in finding aphids in abundance to feed upon. The 14 ovarioles in both the ovaries in the members of the genus *Cryptogonus* of Scymninae may indicate low fecundity that relatively sheltered existence and easy to access to food. The widespread occurrence of high and low ovarioles suuggests that expedience of evolving a high number is as great as evolving low ones. In coccinellid evolution, therefore, ovariole number multiplies and reduces freely in some coccinellids as it has also been observed in Chrysomelidae by SUZUKI (1974).

Further, authors have been able to trace two types of ovaries in Coccinellidae: (a) bases of ovarioles lying at about the same

level and centre of the ovary is not projected upward; (b) bases of the ovarioles lying one above the other and centre of the ovary is projected upward e.g., *Hippodamia variegata* (Goeze) and members of the genus *Lemnia* of Coccinellinae. However, STEIN (1847) reported only former type in Coccinellidae.

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EFFECT OF INSECTICIDES ON *TRICHOGRAMMA CHILONIS* ISHII (HYMENOPTERA: TRICHOGRAMMATIDAE), AN EGG PARASITOID OF SUGARCANE BORERS AND COTTON BOLLWORMS

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The effect of 15 insecticides was studied on the mortality of *Trichogramma chilonis* Ishii and its parasitism under laboratory conditions. The toxic effect of these insecticides on 1, 3, 5 and 7 days old eggs of *Corcyra cephalonica* (Stainton) parasitized by *T. chilonis* was also studied. Among these insecticides, oxydemeton-methyl at 0.06% recorded lowest mortality, maximum parasitism and emergence from the parasitized host.

(*Key words*: *Trichogramma chilonis*, parasitism, insecticides, cotton bollworms, sugarcane borers)

INTRODUCTION

Trichogramma chilonis Ishii is an important egg parasitoid of sugarcane borers and was colonized in the Punjab State. It has established on sugarcane borers, *Chilo infuscatellus* (Snellen) and *Acigona steniellus* (Hampson) (VARMA & SINGH, 1978) and it has also been recovered from eggs of *Earias insulana* (Boisduval) and *E. vittella* (Fabricius) (VARMA *et al.*, 1984). Its population is always low on sugarcane after the winter. The indiscriminate application of insecticides has completely eliminated the egg parasitoids from cotton growing belt of the Punjab (VARMA *et al.*, 1984). The adverse effect of insecticides have been reported on *Trichogramma* brasiliensis Ashmead (AWATE *et al.*, 1977; VARMA & SINGH, 1987) and *Trichogramma achaeae* Nagaraja and Nagarkatti (VARMA *et al.*, 1988). As this parasitoid is being widely employed in different areas of the State, the effect of commonly used insectides on the adults of *T. chilonis* as well as on parasitized eggs of *Corcyra cephalonica* (Stainton) was studied in the laboratory.

MATERIALS AND METHODS

Effect of insecticides on the mortality, rate of parasitism and emergence of *T. chilonis:* The effect of 15 insecticides, as mentioned in Table 1 was studied under laboratory conditions on the mortality of *T. chilonis* and its parasitism. The insecticides and concentration were based on the recommendations of Punjab Agricultural University, Ludhiana against insect pests of cotton. The spray fluid was prepared by mixing commercial products of the insecticides with the tap water (ANON, 1988). Two hundred eggs of *C. cephalonica* mass multiplied on sorghum were mounted on each of the cards (10.0 × 2.5 cm) with gum acacia. The cards were sprayed with different insecticides with an atomizer @ 0.5 ml spray fluid per card. The cards sprayed with the tap water served as control. After drying of spray fluid, each card was exposed in

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TABLE 1. Effect of insecticides on the mortality, rate of parasitism and emergence of *T. chilonis*.

Treatment	Conc. (%)	Mean per cent mortality (after 24 h)	Mean per cent parasitism (after 24 h)	Mean per cent emergence
1. BHC (BHC 50 WP)	0.4	100.0 (90.00)	5.0 (13.53)	16.7 (17.80)
2. carbaryl (Hexavin 50 WP)	0.4	100.0 (90.00)	15.7 (23.67)	15.0 (23.09)
3. cypermethrin (Ripcord 10 EC)	0.016	100.0 (90.00)	2.0 (8.97)	22.0 (20.91)
4. DDT (DDT 50 WP)	0.4	100.0 (90.00)	0.7 (5.73)	0.0 (4.05)
5. DDT + BHC (DDT 50 WP + BHC 50 WP)	0.4	100.0 (90.00)	4.7 (12.41)	74.0 (64.83)
6. deltamethrin (Decis 2.8 EC)	0.0036	87.7 (71.41)	8.0 (16.93)	62.7 (53.91)
7. dimethoate (Rogor 30 EC)	0.06	100.0 (90.00)	49.7 (45.23)	86.7 (69.30)
8. endosulfan (Hexasulfan 35 EC)	0.28	100.0 (90.00)	7.3 (14.52)	13.7 (19.13)
9. fenvalerate (Sumicidin 20 EC)	0.016	100.0 (90.00)	7.0 (15.87)	70.4 (57.82)
10. malathion (Malathion 50 EC)	0.18	100.0 (90.00)	1.0 (6.73)	33.3 (32.70)
11. monocrotophos (Monocil 36 WSC)	0.14	100.0 (90.00)	53.3 (47.23)	75.0 (62.24)
12. oxydemeton-methyl (Metasystox 25 EC)	0.06	18.3 (25.69)	56.0 (48.81)	94.0 (72.10)
13. permethrin (Permacet 25 EC)	0.016	100.0 (90.00)	1.0 (6.73)	16.7 (17.80)
14. phosalone (Zolone 35 EC)	0.25	100.0 (90.00)	17.7 (25.18)	65.7 (52.53)
15. phosphamidon (Dimecron 85 WSC)	0.05	90.7 (75.97)	47.3 (43.75)	86.7 (69.30)
16. Control	—	0 0 (4.05)	71.0 (57.90)	92.0 (74.44)
CD (*P* = 0.05)		(5.85)	(8.16)	(30.86)

Note: Avg. of three replications. Paraentheses are arc sin $\sqrt{p + 0.5}$ transformations.

glass tube (15 × 2.5 cm) to fifty adults of *T. chilonis* for 24 h. Mortality of adults and rate of parasitism after 24 h was observed. In the treatment where *T. chilonis* survived after 24 h another egg card was exposed. Mortality and parasitism was recorded after 24 h. The experiment was replicated thrice and the analysis was done by Completely Randomized Block Design.

Effect of insecticides on the emergence of parasitoids from the parasitized eggs of *C. cephalonica* of different ages: The effect of fifteen insecticides (as mentioned in Table 1) was studied on 1, 3, 5 and 7 days old eggs of *C. cephalonica* parasitized by *T. chilonis*. In each treatment 3 cards each having 200 eggs were exposed to parasitoids prior to spraying and were sprayed at 1, 3, 5 and 7 days after parasitism with the help of atomizer. The spray fluid used per card was 0.5 ml. The cards of control were sprayed with tap water.

In all the treatments, 100 parasitized eggs were kept on each card. The number of parasitoids emerged were counted in each case. The data were analysed by factorial analysis. Both the experiments

were carried out under controlled conditions at 26.1 ± 1.2°C and 72.2 ± 3.1% RH durng June, 1988.

RESULTS AND DISCUSSION

Effect of insecticides on the mortality, rate of parasitism and emergence of *T. chilonis*: *Effect on mortality*: Data presented in Table 1 revealed that all the insecticides except deltamethrin, oxydemeton-methyl and phosphamidon gave 100 per cent mortality of the adults of *T. chilonis*, within 24 h. All the insecticides proved significantly different from control. The lowest mortality (18.3%) was observed in oxydemeton-methyl which was significantly less than all other insecticides. This was followed by deltamethrin which was at par with phosphamidon. The remaining insecticides were at par with each other on the basis of the parasitoid mortality.

The mortality of *T. chilonis* in case of deltamethrin, phosphamidon and oxydemeton-methyl was cent per cent after 48 hours and was significantly more than control (Table 2). The present studies conform with the

TABLE 2. Effect of insecticides on the mortality, rate of parasitism and emergence of *Trichogramma chilonis*.

Treatment	Conc. (%)	Mean per cent mortality (after 48 h)	Mean per cent parasitism (after 48 h)	Mean per cent emergence
1. deltamethrin	0.0036	100.00 (90.00)	11.7 (19.65)	42.7 (40.70)
2. oxydemeton methyl	0.06	100.00 (90.00)	39.3 (38.66)	91.0 (73.11)
3. phosphamidon-	0.05	100.00 (90.00)	16.0 (23.53)	66.7 (56.07)
4. control	—	71.3 (57.65)	45.0 (42.09)	84.7 (67.14)
CD (*P* = 0.05)		(1.80)	(10.76)	(21.83)

Note: Avg. of 3 replications. Parentheses are arc sin transformation.

previous findings regarding phosphamidon, monocrotophos, dimethoate and endosulfan on the mortality of *T. chilonis* (ANON., 1987).

Effect of rate of parasitism: The parasitism above 50 per cent was observed in treatments of monocrotophos and oxydemeton-methyl, which was significantly lesser than control. These two insecticides were on par with dimethoate and phosphamidon. In other treatments, the percentage of parasitism was negligible.

Maximum parasitism was observed in oxydemeton-methyl after 48 h and this treatment was on par with control (Table 2). Deltamethrin and phosphamidon proved inferior to oxydemeton-methyl and control.

Effect of emergence: Maximum emergence of parasitoid was obtained in the treatments of oxydemeton-methyl, dimethoate, phosphamidon, monocrotophos, DDT + BHC, phosalone and deltamethrin and all these insecticides were on par with control (Table 1). All other insecticides gave significantly low parasitoid emergence. The adults emerged in all the treatments were healthy.

Treatments with oxydemeton-methyl gave maximum emergence (91.0%) and was on par with control. However, phosphamidon which was significantly inferior to oxydemeton-methyl, was as good as control. The emergence was poor in deltamethrin (42.7%).

Effect of insecticides on the emergence of parasitoid from the parasitized eggs of different ages: Data presented in Table 3 revealed that insecticidal treatment had no effect on the emergence of *T. chilonis* from 1, 3 and 5 days old parasitized host. However, the emergence was significantly low from the 7 days old parasitized host. More than 60 percent emergence was recorded by oxydemeton-

methyl, dimethoate, DDT, monocrotophos, DDT + BHC, permethrin fenvalerate, deltamethrin, cypermethrin and phosphamidon. However, all these insecticides were significantly inferior to control. The DDT was on a par with oxydemeton-methyl, dimethoate, monocrotophos, permethrin and DDT + BHC, while monocrotophos formed group with permethrin, DDT + BHC, cypermethrin, and fenvalerate. BHC was on a par with cypermethrin, fenvalerate, deltamethrin and phosphamidon. Endosulfan was inferior to all other insecticides except carbaryl, malathion and phosalone which were on par with other.

Six insecticides, DDT, oxydemeton-methyl, dimethoate, monocrotophos, permethrin and DDT + BHC had less effect on the parasitized host while, oxydemethon-methyl was also safe for the adults of *T. chilonis*. Earlier oxydemeton-methyl, DDT and dimethoate have been reported to be safe to *T. achaeae* (VARMA *et al.*, 1978). SANTHARAM & KUMARASWAMI (1985) reported that 0.035% and 0.07% endosulfan, 0.025% monocrotophos and 0.05% phosalone had little effect on the emergence of *T. chilonis* from the parasitized eggs of *E. vittella*. But in the present studies, the performance of endosulfan and phosalone proved more toxic to the parasitoid in the parasitized host. The probable reason was the higher concentration used in the present investigation.

As these insecticides are toxic, there should be waiting period in the insecticidal spray and parasitoid colonization. Oxydemeton-methyl is the best insecticide, but as we cannot depend on one insecticide for the control of bollworms, the insecticides like dimethoate, monocrotophos, deltamethrin, cypermethrin, fenvalerate, permethrin and phospamidon can also be used as parasitoid emergence in all these insecticides was above 60 per cent.

TABLE 3. Effect of insecticides on the emergence of *Trichogramma chilonis* adults from the parasitized eggs of *Corcyra cephalonica* of different age groups.

Sl. no.	Treatment	Conc. (%)	Mean percentage emergence from parasitized eggs of different age (days)				
			1	3	5	7	Mean
1.	BHC	0.4	49.3 (44.62)	66.0 (54.23)	67.3 (55.25)	42.7 (40.73)	56.3 (48.73)
2.	carbaryl	0.4	10.0 (18.27)	6.0 (13.83)	5.3 (13.29)	12.0 (20.08)	8.3 (16.39)
3.	cypermethrin	0.016	86.0 (69.90)	72.0 (58.50)	67.3 (55.13)	25.3 (30.06)	62.7 (53.40)
4.	DDT	0.4	84.7 (69.11)	83.3 (66.32)	94.0 (78.35)	36.0 (36.78)	74.5 (62.64)
5.	DDT + BHC	0.4	82.0 (65.32)	78.7 (64.02)	80.7 (66.21)	48.0 (39.17)	70.3 (58.68)
6.	deltamethrin	0.0036	79.3 (63.49)	60.0 (50.91)	66.7 (54.73)	46.7 (43.06)	63.2 (53.05)
7.	dimethoate	0.06	80.0 (63.68)	86.0 (68.90)	92.7 (74.50)	40.0 (39.07)	74.7 (61.54)
8.	endosulfan	0.28	6.0 (13.31)	12.7 (16.20)	76.7 (61.46)	46.0 (42.68)	35.3 (33.41)
9.	fenvalerate	0.016	54.0 (47.51)	67.3 (55.36)	74.7 (60.50)	58.0 (49.60)	63.5 (53.24)
10.	malathion	0.18	18.0 (24.71)	12.0 (20.22)	3.0 (8.05)	7.3 (15.67)	10.1 (17.18)
11.	monocrotophos	0.14	86.7 (68.70)	78.0 (62.02)	89.3 (62.94)	47.3 (43.46)	72.8 (59.28)
12.	oxydemeton–methyl	0.06	90.0 (76.61)	83.3 (66.14)	65.3 (54.91)	62.7 (52.58)	75.3 (62.31)
13.	permethrin	0.016	82.7 (66.20)	90.7 (75.64)	30.7 (57.28)	36.3 (36.42)	69.8 (58.89)
14.	phosphamidon	0.05	74.7 (60.10)	67.3 (55.61)	61.3 (51.55)	43.3 (41.11)	61.7 (52.09)
15.	phoslalone	0.24	16.7 (23.77)	12.0 (20.12)	9.3 (17.62)	16.0 (23.32)	13.5 (21.21)
16.	Control	—	96.7 (81.40)	96.0 (80.65)	100.0 (90.00)	84.0 (86.50)	94.2 (79.63)
Mean			62.3 (53.55)	60.7 (51.80)	63.4 (53.80)	40.2 (38.77)	

CD ($P = 0.05$)   for treatment : 6.04.
                   for days   : 3.02.
Note: Avg. of 3 replications.   Parentheses are arc sin transformation.

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FIELD RECOVERY OF *TRICHOGRAMMA CHILONIS* ISHII (HYMENOPTERA: TRICHOGRAMMATIDAE) FROM *DEUDORIX EPIJARBAS* MOORE (LEPIDOPTERA: LYCAENIDAE) IN HIMACHAL PRADESH, INDIA

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Field releases of *Trichogramma* spp. viz., *Trichogramma chilonis* Ishii, *Trichogramma exiguum* Pinto, Planter & Oatman, *Trichogramma minutum* Riley and *Trichogramma perkinsi* Girault egg parasitoids have been tried against pomegranate butterfly, *Deudorix epijarbas* Moore in Solan District of Himachal Pradesh. For the first time, *T. chilonis* has been recovered on four occasions from the pomegranate fields showing sign of its establishment in Solan District against *D. epijarbas*. Field parasitism in *D. epijarbas* by *T. chilonis* ranged from 48.9 to 85.5% at various localities. Other *Trichogramma* spp. have not yet been recovered from the released fields.

INTRODUCTION

In recent years, pomegranate butterfly, *Deudorix epijarbas* Moore, has caused severe damage to pomegranate fruit in certain parts of the country (Zaka-Ur-Rab, 1980; Prasad *et al.*, 1987; Kakar *et al.*, 1987). Severe infestation has resulted in the reduction of pomegranate yield as well as the cultivation of this popular fruit in the country. Insecticidal application against this pest has often proved ineffective and uneconomical. Effect of local natural enemies on *D. epijarbas* has mostly been restricted to seasonal and regional pattern of their occurrence. The female butterfly generally lays eggs singly on the surface of fruits, mostly on the inner surface of the calyx during the development of fruits. Based on the encouraging and successful biocontrol results of some lepidopterous pests by *Trichogramma* spp., the study reported in this paper was taken up with the purpose of monitoring the effect of

Trichogramma spp. viz., *T. chilonis* Ishii, *T. exiguum* Pinto, Planter & Oatman, *T. minutum* Riley and *T. perkinsi* Girault on *D. epijarbas* under the mid-hill regions of Solan District during 1987 to 1989.

MATERIALS AND METHODS

The parasitoids were mass-multiplied on the eggs of *Corcyra cephalonica* (Staint), in the laboratory as per the technique described by Balasubramanian & Pawar (1988). The newly emerged parasitoids were kept in the laboratory for one day before the releases, to ensure mating. Field trials were conducted in different localities of the same district. Releases of egg parasitoids viz., *T. chilonis, T. exiguum, T. minutum* and *T. perkinsi* were confined to Salogra, Dharmpur, Arki and Oachghat of Solan District at the rate of 1000 wasps (male and female) per tree per week from May, 1987 to September, 1989.

Recovery tests were made by two different methods twice a month. In the first method, four to seven days after the release

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of parasitoids, the available eggs (15–45) were collected from the released sites and brought into the laboratory and kept enclosed in petri dishes (5 cm dia.) to observe the parasitoids emergence. In the second method, *Corcyra* egg strips were tagged on to pomegranate trees and collected after seven to ten days of tagging to record the egg parasitism. The extent of parasitism worked out in terms of percent parasitism by using the following formula of ROOT & SKELSEY (1969) suitably modified to fit in the present situation.

Percent parasitism = (Total number of eggs parasitised × 100) / (Total number of eggs unparasitised + Total number of eggs parasitised).

Parasitoids obtained so were got identified from the Commonwealth Institute of Entomology, London.

RESULTS AND DISCUSSION

A total of 70,20,000 *T. chilonis*, 23,40,000 *T. exiguum*, 26,96,000 *T. minutum* and 49,30,000 wasps of *T. perkinsi* were released on 22, 11, 12 and 18 occasions respectively against *D.epijarbas* in Solan District of Himachal Pradesh (Table 1).

Recoveries of egg parasitoids from different localities are also given Table 1. Recovery test carried out during 1987, 1988 and 1989 revealed that none of *Trichogramma* spp. could parasitise pomegranate butterfly eggs till June, 1989. The first recovery of *T. chilonis* (63.8–72.3% parasitism) was made in the month of July, 1989 at Salogra where it was released on seven occasions since June, 1987. After that it was also recovered from Oachghat on two occasions July, 1989 (48.9–68.7%) and August, 1989 (70–85.5%) and again from Salogra where recovery was between 50.5–62.3% during August, 1989. It is obvious from Table 1 that the egg parasitism at Oachghat

and Salogra in Solan district ranged between 48.9 to 85.5% minimum and maximum being at Oachghat during the month of July and August, 1989 respectively. The present study also shows that the activity of *T. chilonis* reached its peak during the months of July and August when the temperature and relative humidity varied from 23–27°C and 75–90% respectively in nature in and around Solan (H. P.). The identification and recovery of *T. chilonis* from different localities indicate its establishment in the fields, while other *Trichogramma* spp. could not be recovered under the agro-climatic condition of mid-hill regions in Himachal Pradesh.

Earlier RAWAT *et al.* (1988, 1989) and THAKUR *et al.* (1988) recorded many parasitoids from *D. epijarbas*, but none of the spp. of *Trichogramma* was found to parasitise the eggs of pomegranate butterfly in Himachal Pradesh. KAKAR & SHARMA (1988) have reported reduction in fruit infestation following the releases of *Trichogramma* spp. without making any recovery from the release fields. Therefore, it is doubtful to say that the reduction in pest incidence observed by the KAKAR & SHARMA (1988) without any recovery test was either because of the efficacy of *Trichogramma* spp. or due to some other environmental factors. But, in our present study *T. chilonis* was found to parasitise the eggs of *D. epijarbas* in the laboratory as well as under field conditions. Similarly, AWADALLAH *et al.* (1970) recorded highest percentage of egg parasitisation (30%) in the case of *Virachola livia* Klug with *T. evanescens* Westw in Egypt. The possibilities behind the non-recovery of *T. chilonis* by the earlier workers in Himachal Pradesh, may be either the nucleus culture would not have the pure strain of *T. chilonis* or it may be some other unknown factors.

TABLE 1. Details of the biocontrol trials conducted against *Deudorix epijarbas* in Solan District of Himachal Pradesh.

Month & Year	Locality	Number of *Trichogramma* spp. released				Recovery test	
		T. chilonis	*T. exiquum*	*T. minutum*	*T. perkinsi*	Parasitoid	Parasitism*%
May, 1987	Dharampur	1,20,000	1,80,000	60,000	2,40,000	—	—
June, 1987	Salogra	1,00,000	80,000	—	1,80,000	—	—
July, 1987	Salogra	2,60,000	—	—	1,20,000	—	—
Sept, 1987	Oachghat	1,20,000	1,00,000	46,000	4,80,000	—	—
June, 1988	Dharampur	—	40,000	—	1,20,000	—	—
	Salogra	1,60,000	—	—	2,00,000	—	—
	Oachgat	2,70,000	—	—	—	—	—
July, 1988	Dharampur	—	—	—	1,00,000	—	—
	Arki	80,000	—	60,000	1,00,000	—	—
	Salogra	1,30,000	—	—	—	—	—
	Oachghat	—	—	—	20,000	—	—
August, 1988	Salogra	60,000	—	—	—	—	—
	Dharampur	—	—	—	60,000	—	—
	Arki	1,40,000	—	—	—	—	—
Sept., 1988	Salogra	1,80,000	—	1,10,000	—	—	—
	Oachghat	2,00,000	—	—	—	—	—
	Arki	3,40,000	90,000	1,50,000	—	—	—
October, 1988	Oachghat	80,000	—	50,000	—	—	—
June, 1989	Salogra	20,00,000	—	3,80,000	5,60,000	—	—
	Dharampur	—	—	2,10,000	1,30,000	—	—
July, 1989	Salogra	10,10,000	4,20,000	2,60,000	—	T.chilonis	63.8–72.3
	Oachghat	5,80,000	2,20,000	6,80,000	7,80,000	*T.chilonis*	48.9–68.7
	Dharampur	—	3,10,000	2,30,000	2,40,000	—	—
August, 1989	Oachghat	4,20,000	—	—	3,30,000	T.chilonis	70–85.5
	Dharampur	5,80,000	4,80,000	4,60,000	6,10,000	—	—
	Salogra	50,000	2,40,000	—	2,00,000	*T. chilonis*	50.5–62.3
Sept., 1989	Salogra	80,000	—	—	4,60,000	—	—
	Oachghat	60,000	1,80,000	—	—	—	—
Total from 1987 to 1989		70,20,000	23,40,000	26,96,000	49,30,000	—	**48.9–85.5

* Range of average percent parasitism recorded twice in a month at each locality.

** Minimum and maximum percent parasitism.

It is concluded from the present study that since the exotic parasitoid *T. chilonis* gave encouraging results (48.9 to 85.5% parasitism), it is worth to exploit this egg parasitoid on a large scale against *D. epijarbas* to check the population of this pest in the fields. Further, the recovery of *T. chilonis* in the fields is of tremendous importance since it can be reared in large scale on *Corcyra* eggs under laboratory conditions throughout the year for field releases.

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STUDIES ON THE LIFE HISTORY AND DEVELOPMENT OF *ORTHOGALUMNA TEREBRANTIS* WALLWORK, AN EXOTIC ORIBATID OF *EICHHORNIA CRASSIPES*

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The life history of *Orthogalumna terebrantis* Wallwork (Acarina : Galumnidae), an exotic oribatid mite introduced for biological control trials against water hyacinth, was studied under laboratory conditions. It completed its life cycle in 25-27 days. Eggs were laid within leaf laminae and the feeding of the larval and nymphal stages caused yellow linear mines on the leaf. Adults were observd to live for 78.75 days, a female laying an average of 58.5 eggs.

INTRODUCTION

Orthogalumna terebrantis Wallwork (Acarina: Galumnidae) an exotic oribatid (origin: South America), considered as one of the five potential biocontrol agents of water hyacinth (Benett & Zwolfer, 1968; Coulson, 1971; Perkins, 1974), was introduced to India in 1982, under the AICRIP on biological control of crop pests and weeds, for trials against water hyacinth. Successful establishment of this mite has been achieved in released sites in Bangalore (Jayanth & Ganga–Visalakshy, 1989), although the effect on the plant is yet to be assessed.

Very little information is available on the life history, fecundity and longevity of *O. terebrantis*. An attempt was made therefore to gather more information on the biology of this mite. The studies were carried out in the laboratory at 26 $\pm 1°C$.

MATERIALS AND METHODS

Fifty adults of *O. terebrantis* were released on the young central leaf of a water hyacinth plant and covered by an aerated polythene cover, the mouth of which was closed tightly by a thread tied to the base of the petiole. After 10–12 h, the cover was removed and all the mites were collected back to prevent fresh oviposition. The leaf was checked for eggs and observations on the duration of various stages were recorded. The experiment was replicated ten times.

For longevity tests, a leaf with inactive tritonymphs was taken and kept in a petridish, with moistened filter paper disc at the base. Adults that emerged after 2–3 days were collected and placed individually in glass vials (7 × 5 cm), provided with a narrow strip of hyacinth leaf. The mouths of the tubes were closed tightly with a closely knitted longcloth, held by rubber bands. These tubes were later kept inside a plastic jar (12.5 × 10 cm) with a ventilated lid and moistened sponge at the base to provide adequate humidity. The leaf strip was changed once in 2–3 days and observation on longevity was recorded.

Ten freshly emerged adults were released in a trough containing 10-15 plants, for recording fecundity. The leaves were examined regularly and those with yellow

specs were removed, checked under the microscope and observations on the number of immature stages and eggs were recorded.

To ascertain whether reproduction occurs sexually or partheongenetically, inactive tritonymphs were collected out from the galleries and kept separately in small vials for emergence. After emergence, individual mites were separately released in troughs containing 2–3 fresh plants and observations recorded for the presence of galleries at weekly intervals.

RESULTS AND DISCUSSION

Females of *O. terebrantis* make circular hole, .075 - 1 mm in diameter, with their mouth parts, eating off the leaf tissue, on the lower surface of the leaf. They lay solitary eggs mostly sideways to the oviposition hole, deeply embedded in the aerenchyma cells. This type of concealed oviposition behaviour was observed in other phytophagous oribatid mites like *Punctoribates longiporosus* and *Scheloribates decarinatus* Akoi, occurring on water hyacinth and *Chromolaena odorata* respectively, which could prevent the egg from predators, washing away by running water and other adverse climatic conditions (HAQ & RAMANI, 1985). During the present study, it was observed that very slight disturbances caused females to abandon half made holes and this probably accounts for the absence of eggs in some holes in a leaf.

Life cycle:

O. terebrantis has a shorter development period (25.5 days) (Table 1) as compared to that of *S. decarinatus* Akoi, which takes 37.8 days at 27 $\pm$ 1°C. (RAMANI & HAQ, 1987). As in other Plant feeding oribatids like *P. longiporosus* and *S. decarinatus* (HAQ & ADOLPH 1981), *O. terebrantis* also has a larval and nymphal stages (Proto, deuto- and tritony-

mph), with a quiescent and inactive premoulting period between the nymphal stages.

Eggs: Eggs are white, elliptical, translucent, smooth with no surface ornamentation and uniformly distributed cytoplasm. The incubation period lasts 7.6 days. The egg measures .17 mm in length and .099 mm in width.

Larva: An amber coloured active hexapod larva hatches from the egg. The larval period lasts for 2.6 days. This stage was followed by an inactive period of 1 day. The larva as soon as it hatches, started feeding on the surrounding tissues resulting in yellow specs externally on the leaf. The holes with no eggs start turning brown from the edges after 4–5 days.

Nymph: The larva is succeeded by three nymphal stages viz., proto-, deuto- and trito-nymphs. The former two stages are alike externally, except for the slight increase in size of the deutonymphs while the tritonymphs can be differentiated easily. Continuous feeding by the nymphs cause formation of galleries in the leaf, which appear as yellow streaks externally on the leaf. Accumulation of frass gives a darkened basal portion to the galleries.

Protonymph: The protonymphs can be differentiated from the larva by the appearance of the fourth pair of legs. This stage lasts for 2 days followed by an inactive stage of 1.7 days. The nymphs measure .28 mm in length and .10 mm in width with the gallery length reaching to 1.33 mm.

Deutonymph: The deutonymph period lasts for 2.4 days with an inactive period of 1.5 days, reaching a maximum of .34 mm in length and .15 mm in width a gallery length of 1.74 mm.

Tritonymphs: This stage was the longest period among the larval and nymphal, lasting

TABLE 1. Duration of different stages of *O. terebrantis* with their measurement and length of galleries attained during each instar.

Stage	Duration*	Measurement of the stages*		Total length of gallery* in mm
		Length in mm	Breadth in mm	
Egg	7.6 days	.15	.099	—
Larva	2.6 days	.17	.09	.71
Ist inactive stage	1 day	—	—	—
Protonymph	2 days	.28	.10	1.33
Inactive stage-II	1.7 days	—	—	—
Deutonymph	2.4 days	.34	.15	1.74
Inactive stage -III	1.5 days	—	—	—
Tritonymph	3.2 days	.43	.22	2.41
Inactive stage-IV	3.5 days			
Adult		.43	.26	
Total duration	25.5 days			

* Mean of 10 replications.

about 3.2 days of active period followed by an inactive period of 3.5 days. They attain more or less the adult size, measuring .43 mm in length and .22 mm in width with a gallery length of 2.41 mm. The tritonymphs can be differentiated from proto- and deuto-nymphs by the pronounced darkened dorsal sclerite. Similar observation was also made by WALLWORK (1965). As the stage proceeds there is an unequal widening of hysterosoma leading to a bulged abdomen with a small pointed gnathosoma.

The oviposition habit, formation of galleries by the larval and nymphal stages and the completion of life stages inside the galleries of *O. terebrantis* are similar to that of *P. longiporosus* (HAQ & RAMANI, 1985). The duration of development of *O. terebrantis* is shorter when compared to other primitive oribatids like *Lepidocarus ornatissimus* (178.4 days) and *Archegozetes longisetosus* (34.4 days) and similar to higher oribatids like *Galuma flabellifera orientalis*

(24.8 days) and *G. longipluma* (24.5 days) (HAQ & ADOLPH, 1981).

During the present study, it was observed that the larval and nymphal stages completed their development inside a single gallery. But if tritonymphs were taken out of the galleries and placed on a leaf they were able to make fresh galleries and complete their life cycle, which differs from the earlier report by CORDO (1976), where tritonymphs in the lab. during their development left the galleries and began a new one on a leaf. The galleries are linear, extending from base to apex of the leaf or vice-versa. At times, nymph crosses a vein and continues its gallery in the neighbourhood intravenal area, leading to the formation of two adjacent ones by a mite.

Adult: Fully formed adults emerge by making holes (.25 to .35 mm in diameter) either on the lower or upper surface of a leaf. The adults are tiny, brownish black

coloured, tear drop shaped, found normally congregated on fresh wounds or on the ventral surfaces of young leaves. The newly formed adults remained inside the gallery up to one day, even after making emergence holes.

Effect of mites on the plant:

Females prefer the young central leaves for oviposion. The eggs are laid uniformily except for the thickened basal part of the petiole. In a plant infested with *O. terebrantis,* the youngest leaves contain oviposition holes, younger ones, larval and nymphal stages and the older leaves harbour nymphal stages and the oldest with matured tritonymphs and adult emerged galleries. As the nymphs develop, the adjacent galleries meet together and this leads, in severe infestation, the complete browning appearances of the leaves, which starts drying up from the tip. As only the oldest leaves are affected by the mites, their effect on the plant is not prononuced, to hinder the development of the plant. In severely infested leaves, up to 120 galleries could be counted per cm^2 and as much as 6,400 galleries per leaf.

Longevity: When adults were provided leaves with feeding spots of *Neochetina* spp. and 65–75% RH, they survived for 73.75 ± 37.98 days and with humidity alone 38.2 ± 14.32 days (Table 2), which differs from the observation made by CORDO & DEBACH (1975), who had recorded 46.0 days when leaves with feeding spots of *Neochetina* spp were provided and 15.4 – 19.7 days with 100% RH alone. When mites were kept without humidity and food, they survived only for 1–2 day.

Reproduction: O. terebrantis are capable of reproducing parthenogenetically. In the seven sets of tests conducted by releasing fresh adults that emerged from isolated tritonymphs, oviposition and gallery formation was observed in two sets. Further gallery formation, in these samples could be stopped by locating and removing the released adults. Although males were present(HAQ, 1988 ;Personal communication), these could not be differentiated in live adults and mating pairs were never noticed in the culture.

Fecundity: A female after a preoviposition period of 1–2 days produces an average of 58.5 eggs during its life time, which is 50% more than the early report of 21.2 and 23.91 ♀ 10–30° and 15–35°C respectively. (DEL-FOSSE, 1977). Even though egg laying is observed throughout the life of the adult, maximum numbers are laid during the latter half.

TABLE 2. Longevity of *O. terebrantis*, under varied conditions.

Sl. no.	Particulars	No. of days alive
1	Food plus humidity (65–75%)	73.75 ± 37.95
2	Humidity alone	38.2 ± 14.32
3	No food plus no humidity	1–2 days

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IMPROVED TECHNIQUE FOR MASS REARING OF
SPODOPTERA LITURA (LEPIDOPTERA : NOCTUIDAE)

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An improved mass rearing technique for *Spodoptera litura* (Fabricius) has been evolved in which usual difficulties like dispensing of diet, handling of neonate larvae and harvesting of pupae have been overcome. The technique involves group rearing of larvae in two stages with minimum possible handling.   Containers used for rearing are large size petridishes and plastic boxes which can be conveniently stacked in the racks and thus occupies less space.   The unique feature of the technique is that excreta never mix with the diet, thus fresh surface of diet is always available to the larvae.   Required qualities of containers such as, provision for gas exchange, moisture regulation, visibility and accessibility, convenience in handling, ease in cleaning and disinfecting, reusability etc., are fully met.   The technique has proved to be efficient and economic in comparison to individual rearing.

(*Key words:*   mass rearing, *Spodoptera litura*)

INTRODUCTION

The ability to mass rear high quality insects consistently, has become necessary for modern pest management strategies (like sterile insect release, hybrid sterility, conditional lethal mutation, translocation sterility and biological control using parasitoids, predators and pathogens).   Mass rearing technique of *Spodoptera litura* (Fabricius), a polyphagous noctuid of much economic importance has been developed by SHOREY & HALE (1965), CHU *et al.* (1976), BOARDMAN (1977), OKADA (1977), GUPTA & PAWAR (1985).   All of them have reared the larvae individually on semi-synthetic diet in glass vials or cups.   SINGH & SURRY (1980) have reared *S. litura* in group.   Problems encountered in handling of neonate larvae, dispensing of diet into vials or cups and involvement of excess labour have been some of the limiting factors for the large scale production of this insect.

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MATERIALS AND METHODS

S. litura has been reared in our laboratory individually in glass vials on semi-synthetic diet for over ten years.   A technique for mass rearing *S. litura* using large size petridishes and plastic boxes has been developed, wherein the above mentioned problems have been greatly solved and at the same time the quality of the insect has been improved. *S. litura* is now being reared by this technique in our laboratory since January, 1988 till today.

Diet dispensing: Semi-synthetic diet (NAGARKATTI & SATYA - PRAKASH, 1974) is prepared and poured hot in petridishes $(21 \times 2.5$ cm).   Approximatley 20% of the diet prepared is poured @ 200 ml per petridish while remaining 80% of diet is poured at about 500 ml per petridish.   Both petridish and its cover can be used for pouring diet.   On cooling, the diet solidifies and then plate can be inverted one over the other and lid over the lid as shown in Fig. 1. This arrangement prevents the loss of water

content due to evaporation. Diet is then stored in the refrigerator.

Early instar larvae rearing unit: Early instar larvae rearing unit was prepared by placing a sponge piece of 25 × 25 × 0.5 cm on a glass sheet of 25 × 25 × 0.2 cm. The sponge is covered with a single layer of soft tissue paper. A small plate (3 × 0.5 cm) containing sterilized eggs (ca. 200) of *S. litura* is placed in the centre over the tissue paper. A petridish (21 × 2.5 cm) having about 200 ml of diet is placed inverted over the tissue paper as shown in Fig. 2. After the eggs are hatched the neonate larvae crawl and spread on the diet.

Late instar rearing unit: The translucent rectangular plastic boxes (28 × 18 × 6 cm) with lid, are modified to rear late instar larvae. One window (10 × 2.5 cm) each on four sides of the box is cut and covered with a fine hardware cloth. The windows could provide sufficient ventilation to prevent moisture accumulation inside the box. A 2 cm thick layer of the sterilized sand is spread at the bottom of the box. A small piece of the tissue paper (15 × 15 cm) is kept at the centre of the sand. The diet in the petridish containing ca. 200 larvae (10 days old) is devided into 5 equal pieces using a spatula. One piece of diet bearing ca. 40 larvae is kept in each plastic box
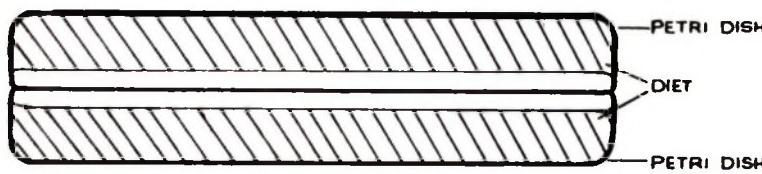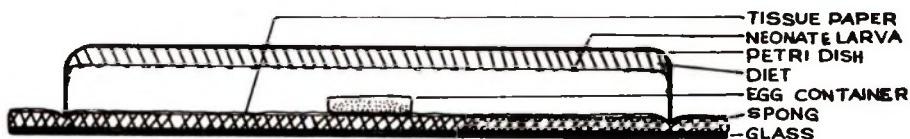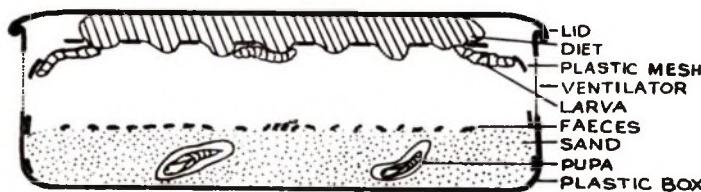
Figures 1–3.   1. Positioning of petridishes for sorting diet in refrigerator. 2. Rearing unit for early–instar larvae. 3. Rearing unit for late-instar larvae.

over the tissue paper. A hard plastic mesh (26 × 22 cm) with holes (2 × 1.5 cm) is fitted into the box in such a manner so that it forms a crest higher than the brim of the box. Thick cake of the diet (about 500 ml) in a petridish is provided into two equal pieces. One such piece is kept on the top of the crest and the lid of the box is then tightly fitted so that the diet and mesh crest become flat just beneath the lid as shown in Fig. 3.

The boxes are stacked and left for 8 days after which another piece of fresh diet is kept on the crest. After 20 days from hatching, the larvae bury themselves in sand and start pupating. In a period of 25 days all the larvae pupate and chitinization is also completed, the boxes are now ready for pupal harvest.

Harvest and sterilization of pupae: The sand is separated by steel wiremesh (mesh size 3 × 3 mm). Pupae are then separated from the larval excreta and collected in a bag made of mosquito net. The bag containing pupae is then dipped several times in a jar under the running tap water and then dipped for 10 minutes in a jar containing 0.05% solution of sodium hypochlorite (NaOCl) (IGNOFFO & DUTKY, 1963). The pupae are dried and sorted sex wise and kept in the folds of soft tissue paper for adult emergence.

Handling of adults and eggs: On emergence of moths, 8 pairs are transferred per oviposition cage. The oviposition cage is made of 2 litre clean plastic jar. Diluted honey (15%) is provided for feeding the adults. A sheet of paper is accommodated inside the jar so that it stays along with the wall of the jar and provide suitable substrate for the moths to deposit the egg masses. Eggs are laid on the paper which are removed on alternate days. Eggs are then sterilized in 0.05 percent solution of NaOCl for 5 minutes.

Sterilization of equipments: Glass petridishes and sand are sterilized in hot air oven at 150°C for 4 hours. Plastic boxes, plastic mesh and sponge sheets are sterilized in 0.01% NaOCl solution for half an hour and sun-dried.

RESULTS AND DISCUSSION

The laboratory culture of *S. litura* is generally maintained on castor leaves in plastic containers or in specimen vials 7.5 × 2.5 cm on semi-synthetic diet. In the former method there is a need of regular availability of castor leaves. Secondly, during the last instar the excreta contaminate leaves and render them unfit for consumption. When rearing on artificial diet in specimen vials, dispensing of diet, transferring of neonate larvae, cleaning and sterilization of glass vials is cumbersome. In this method the aforesaid operations are done in an efficient and simplified way, besides, there are other advantages which contribute towards the quality and economy in the mass rearing. In the early instar rearing unit the sponge layer serves two purposes; (a) it prevents the escape of neonate larvae, (b) it prevents the accumulation of excess of moisture inside the petridish. In the late instar rearing unit the larvae crawl and perch on the mesh and feed from the ceiling. The faecal matter drops on the sand and does not mix with the diet. Fresh surface of diet is, therefore, always available to the larvae. The moisture of the excreta is absorbed by the sand which help in checking the fungus growth. However, during last 3–4 days of larval stage the food consumption is maximum and so is the faecal matter. Just 2–3 days prior to pupal harvest, fungus starts developing on the superficial layer of faecal matter but this does not interfere in any way with the larvae/pupae, as by that time they are buried in the sand for pupation.

Quality of insects: The quality of insect is an important consideration in mass rearing technique. The individual weight of 35 pupae reared individually on semi-synthetic diet in glass vails (2.5×7.5) were compared with the weight of 35 group-reared pupae. Average weight of group-reared pupae $(0.435 \pm 0.055$ g) was found to be significantly more than the individually reared pupae $(0.351 \pm 0.039$ g). The CD (at $P = 0.05$) being 0.0228 g. The increase in weight of pupae may be attributed to the ample space available per larva. Each larva gets ca. 50 cc of space as compared to 20 cc when it is reared on glass vial. Simulation of natural conditions like moist sand for pupation could be other reason for better results.

Labour economy: Usually, dispensing of diet, handling of neonate larvae harvesting of pupae, washing of containers involve considerable time in the mass rearing of noctuids. All these activities are so simplified that one person working for 7 hours a day can rear 1000 pupae everyday. The distribution of time in various activities is as given below.

Preparation of 7.25 litres of diet and dispensing in petridishes	1 h
Setting of 5 neonate larvae rearing units	1/2 h
Setting of 25 late instar larvae rearing unit	2 h
Harvesting of pupae from 25 units	1 h
Setting of oviposition cage, collection and sterilization of egg to obtain approx. 2,000 eggs	1/2 h
Washing and sterilization of equipments	2 h
Total time	7 h

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BIOLOGY OF POTATO TUBER MOTH, *PHTHORIMAEA OPERCULELLA* ZELLER WITH SPECIAL REFERENCE TO PUPAL EYE PIGMENTATION AND ADULT SEXUAL DIMORPHISM

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Life history studies on potato tuber moth, *Phthorimaea operculella* Zeller, a serious pest of potato were carried out on a laboratory maintained culture. The present paper deals specifically with the pupal period during which five stages have been differentiated on the basis of eye pigmentation. The sexually dimorphic characters of the adults have been described. The male and the female adults differ from each other not only on the basis of morphological characters but also in longevity. Total life cycle of the insect pest is completed in 21 days.

INTRODUCTION

The potato tuber moth, *Phthorimaea operculella* Zeller (Lepidoptera: Gelechiidae) is one of the most destructive pests of potato causing severe damage to the plants as well as the tubers. The larva mines the foliage, stem and tuber in field as well as under storage. In India, 30 to 70% tubers are infested under different indigenous methods of storage (LALL, 1949; SEN, 1954; WESLEY, 1956). In hilly regions of India, the infestation is 25 and 95% in stores and field conditions, respectively (SEN, 1954; LAL, 1988).

Although the life cycle of this insect pest has been studied in many countries (MUKHARJEE, 1949; NIRULA, 1960; STANEV & KAITAZOV, 1962; DORESTE & NIEVES, 1968; BROODRYK, 1971; AL-ALI *et al.*, 1975; FOOT, 1979; GOMMA *et al.*, 1979), no detailed studies have been made in relation to adult sexual dimorphism and eye pigmentation of pupa.

MATERIALS AND METHODS

The culture of potato tuber moth was collected from the experimental fields of Central Potato Research Institute, Shimla, and was reared for several generations on potato tubers in the laboratory, in a BOD incubator under controlled temperature 27± 2°C and photoperiod, 12 L:12 D.

Adults were kept in small plastic jars, covered with double layered muslin cloth which acted as an ideal ovipositional substrate (FENEMORE, 1978). Adults were fed with 5% sugar solution, placed in small injection vials and plugged with cotton-wicks. Eggs were collected from muslin cloth, with the help of a fine camel hair brush. Freshly collected eggs were transferred to punctured potato tubers, kept on 3 to 4 cm layer of sterile sand in a jar.

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In the present investigations, the following aspects of life history were studied and daily observations were taken at hourly intervals from 0600 to 2100 h (1) hatchability of eggs; (2) number and duration of different larval instars; (3) duration of different pupal stages based on the eye pigmentation; (4) sexing of adults; (5) fecundity rate of female adults; and (6) longevity and sex- ratio adults.

The exact number of larval instars was calculated by measuring the width of head capsule at different developmental stages.

RESULTS AND DISCUSSION

Among different life stages of potato tuber moth, larva is the only destructive stage, which causes damage to potato tubers. Damage is minor during 1 to 3 days after infestation, but becomes severe in the next 8 to 9 days. Infested potatoes can be easily distinguished from the healthy ones by the presence of dark brownish excretory pellets on the tubers.

Potato tuber moth lays fertilized and unfertilized eggs and only the former hatch into larvae. EL-SHERIF et al. (1979) have also reported unfertilized eggs in this insect. The present hatchability of eggs is 92.00. Fertilized eggs are longer $(0.49 \pm 0.02$ mm) than the unfertilized eggs $(0.42 \pm 0.02$ mm) but lesser in width $(0.33 \pm 0.02$ mm) as compared with the latter $(0.37 \pm 0.03$ mm). This stage lasts for 3.5 ± 0.806 days.

Each larva has four distinct instars, as shown by the width of head capsule, which falls into four non-overlapping classes. The width of head capsules of first, second, third and fourth instar is 0.198 ± 0.007 mm 0.331 ± 0.005 mm, 0.592 ± 0.284 mm and 0.907 ± 0.015 mm and these stages last for 3 days, 2 days, 3 days and 4 days respectively. No sexual dimorphism is

observed till the third larval instar. However, in the fourth larval instar, males are distinguishable from the females by the presence of two elongated yellowish testes in the fifth and sixth abdominal segments, which are visible through the larval skin.

The larva becomes full fed in 10 days and then enters into prepupal stage. Pupation in laboratory conditions is observed among the sand particles or in between the filter papers. Pupal stage lasts for 5.5 ± 1.360 days and there is clear distinction between male and female pupa (CHAUHAN & VERMA, 1982). There is a gradual change in eye pigmentation and on the basis of this the pupae are classified into five categories.

(1) *Yellow eye pupa:* Eyes of newly formed pupa are yellow in colour each with a black spot in the centre. This stage lasts for 35 to 48 h.

(2) *Early red eye pupa:* In the next 8 to 10 h the red pigment starts spreading from the corner towards the centre of the eyes. Black spot also starts shifting towards the corner of the eyes.

(3) *Middle red eye pupa:* In this stage exactly half of the eyes are red in colour while the rest are yellow. This stage lasts for 8 to 10 hours.

(4) *Late red eye pupa:* Red pigment spreads in the entire eye and this stage lasts for 28 to 30 h.

(5) *Black eye pupa:* In the next 35 to 37 h colour of the eyes changes to dark brownish black.

In insects the change in eye colour is due to change in eye pigments and predominance of one pigment over the other (SUMMERS et al., 1982).
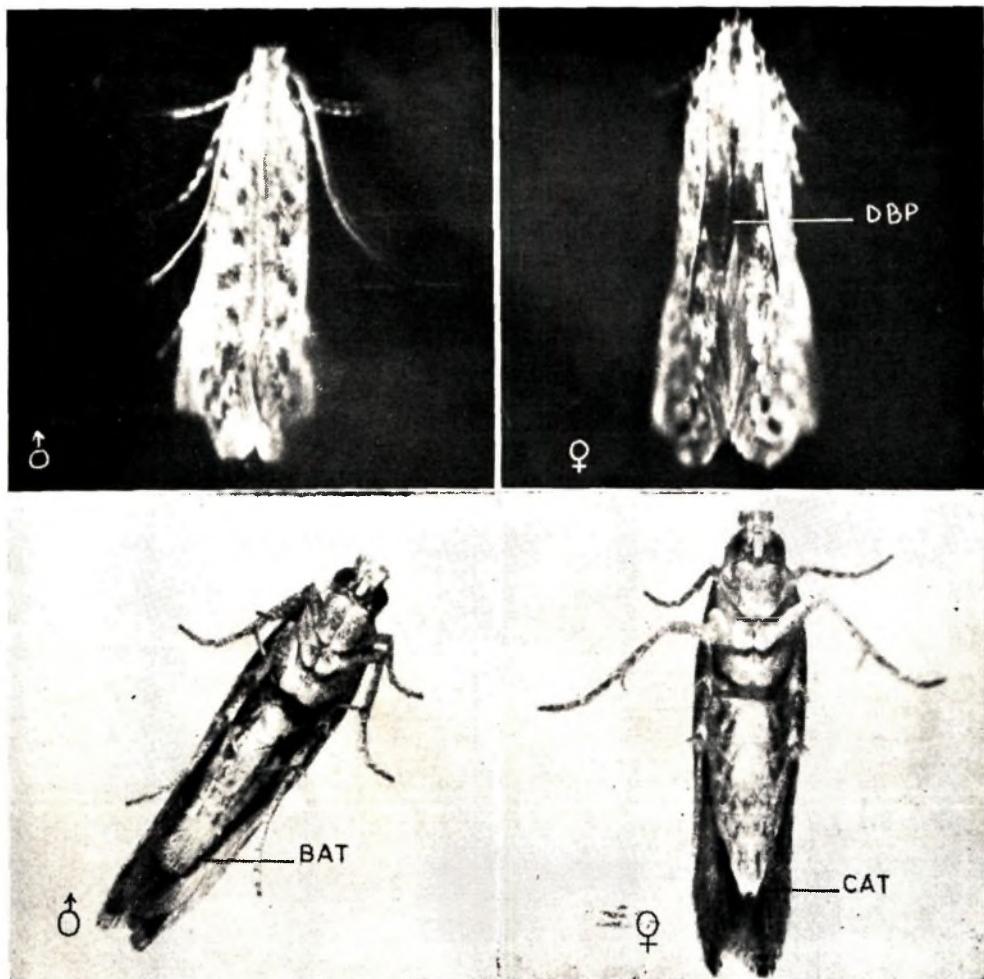
Figs. 1, 2: Dorsal view of male and female potato tuber moths; Figs. 3, 4: Ventral view of male and female potato tuber moths.

Abbreviations used:

BAT	:	Broad Abdominal Tip.
CAT	:	Conical Abdominal Tip.
DBP	:	Distnct B!ack Patch.

Adults of potato tuber moth differ from each other dorsally as well as ventrally (Figs. 1, 2). Dorsally, female moth is having a dark black patch of scales in the middle of the wings (Fig. 2) and ventrally, the shape of male abdominal tip is broad due to the presence of external genitalia, but abdominal tip of females is conical (Figs. 3, 4). The body length of males (6.10 $\pm$ 0.10 mm) is comparatively more than the female moths (5.92 $\pm$ 0.20 mm), but lengths of forewing (7.30 $\pm$ 0.20 mm), hind-wing (5.82 $\pm$ 0.09 mm) and antennae (5.20 $\pm$ 0.20 mm), of females are more than the corresponding values (6.10 $\pm$ 0.10 mm, 5–10 $\pm$ 0.10 mm and 4.66 $\pm$ 0.10 mm) for males. The wing span of female moth (14.40 $\pm$ 0.40 mm) is larger than the male moth (13.00 $\pm$ 0.31 mm). The longevity of male adult (14 $\pm$ 1.28 days) is more than the female moth (9.1 $\pm$ 2.71 days). These studies on adult longevity do not correspond with those of EL SHERIF et al. (1979), who reported the opposite trend. The ratio of male to female in the present investigations s 1.1 : 1.0 which also does not correspond

with those of GUBBAIAH & THONTADARYA (1977), who made such studies on this insect under field conditions.

Female moths lay an average of 208 $\pm$ 27.455 eggs during life span and the maximum number of eggs are laid on the third day after emergence (Fig. 5). For the act of oviposition, female moth prefers rough surface, as maximum number of eggs are laid on the muslim cloth than on the smooth surfaces of the plastic jar. This finding is in accordance with that of FENEMORE (1978).

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Fig. 5: Effect of age on average fecundity rate at 27 $\pm$ 2° C in potato tuber moth.
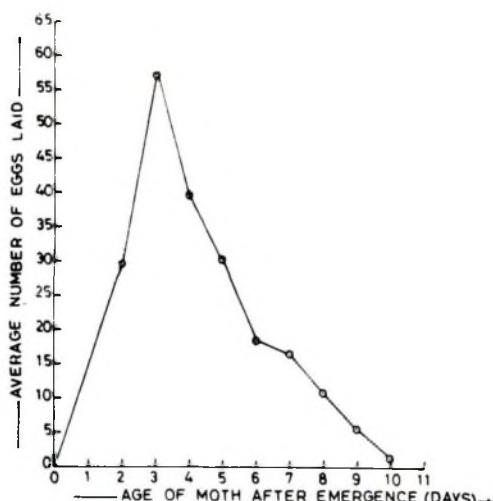
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REARING OF *EUPROCTIS FRATERNA* MOORE (LYMANTRIIDAE : LEPIDOPTERA) ON ARTIFICIAL DIET

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Rearing of *Euproctis fraterna* **Moore on an artificial diet is described. The normal developmental period for larvae reared from egg to pupa on the described diet was 40-45 days. The mean adult female life span was 8.5 days and average fecundity was 155 eggs. A colony of** *E. fraterna* **was successfully reared for 6 successive generations using this diet and rearing procedure.**

INTRODUCTION

Euproctis fraterna Moore is a polyphagous lymantriid. It is a sporadic pest of castor and the larvae are defoliators on cotton, pomegranate, rose, mango, pigeon pea and pear (Nayar *et.al*, 1976). Because of its potential economic importance, a colony of *E. fraterna* was established for studies on the biology and control of this insect. Larvae were reared on castor leaves (*Ricinus communis*), and although the practice was successful initially, after several generations a polyhedrosis virus decimated the colony.

Artificial diets have been developed and documented for various lymantriids e.g., *Hemerocampa pseudotsugata* (Douglas fir tussock moth), CHAUTHANI et al., (1968); LYON et al. (1966); *Porthetria dispar* (L) (gypsy moth), LEONARD et al. (1966); MAGNO-LAR, (1970); ODELL et al., (1966); VASILJEVIC et al., (1971) etc. However, so far there are no reports of an artificial diet for *Euproctis fraterna*. Our successful attempts in developing an artificial diet and standardising rearing procedures for this insect are reported here.

MATERIALS AND METHODS

Cicer arietinum flour (105 g, dry weight), agar (12.45g), sorbic acid (1 g), ascorbic acid (3/25 g), methyl-p-hydrobenzoate (2 g), sucrose (2.5 g), brewers yeast (10 g), streptomycin sulphate – sold under the name "Ambistryn" (manufactured by Sarabhai Chemicals) (0.25 g), multivitiamin– sold under the name "Becadexamin" (manufactured by Glaxo) (1.25 g), 2 ml of 10% formaldehyde, were used to prepare an artificial diet for the test insect *E. fraterna*.

The diet was prepared as follows. The agar was dissolved in 500 ml of boiling, distilled water. After the agar solution had cooled to 65 to 70°C, all ingredients except brewer's yeast, multivitamin and streptomycin sulphate were placed in a 2 litre capacity glass beaker and the mixture was blended for 10 min with the help of a power driven homogenizer fitted with disc-type metallic blade. The mixture was autoclaved at 15 psi/120°C for 10 min and then cooled to 60°C before adding the mixture containing brewer's yeast, multivitamin and streptomycin sulphate in 280 ml

of ditilled water. The whole mixture was further blended for 10 min. The hot diet was poured uniformly into shallow aluminium trays and allowed to solidify at room temperature. The diet once prepared was either used immediately or stored at 4–10°C.

The test diet was devised by DANG *et al.* (1970) and further slightly modified by NAGARKATTI & PRAKASH (1974). In our case we have further modified it by adding another component i.e., sucrose.

Rearing procedures

The adult females normally oviposited on the sides or the base of holding cages. The eggs, which were light green in colour became dark brown within 3 to 4 days. At this time, the diet weighing ca. 2 g per piece was provided on a piece of filter paper placed on the base of the holding cage. The diet was replenished after every 3 days of larval life, till pupation.

Bristles present on the dorsal surface of the larvae tend to fall off on touch. These become airborne and are probably the cause of mild irritation to eyes and hands of handlers. For the insect, this may be a defensive adaptation. Rubber gloves and eye masks had to be used to avoid these hazards. Larvae were also reared on fresh castor leaves, provided daily to compare efficacy of the artificial diet. In this case bouquets of castor leaves were kept moist by placing their stems in vials of tap water. Holding cages and other conditions were identical to the rearing procedures for the diet fed insects.

After eclosion, the adults in both cases were maintained in the holding cages and supplied with 10% honey solution. Oviposition usually began 3 days after emergence.

To determine longevity and fecundity for females obtained from larvae reared on the artificial diet, they were segregated after mating (4 days) and then placed individually in 3 litre capacity plastic containers lined at the bottom with filter paper, and provided with honey solution until they died.

All rearing and maintenance procedure were conducted at 28 ± 2°C, 65–70% RH and a 12:12 L:D photoperiod.

RESULTS AND DISCUSSION

Suitability of an artificial diet can be gauged by comparing the developmental time, survival rate and pupal weight of larvae reared on the diet with those reared on natural food, castor leaves in this case. The developmental time from egg to pupa for diet reared larvae was ca. 40–45 days, whereas those reared on natural diet require 38–41 days. Though the developmental time for larvae reared on the artificial diet was only slightly more than those reared on castor leaves, the pupal weight (average 175.5 ± 12.4 mg) of the former was significantly greater than that of pupae (average 140 ± 8.4 mg) obtained from the natural diet. Additionally, the survival rate for larvae reared on the artificial diet ranged from 75 to 90% in comparison with 40 to 75% for those reared on castor leaves. The lower survival rate in the latter case was mainly due to nuclear polyhedrosis virus disease.

In the study of adult longevity and fecundity, females reared on the artificial diet survived from 7 to 12 days (average 8.5 days) and laid from 0 to 300 eggs, the mean value being 155. A few females did not ovipoist and these were not included in the counts.

It was possible to maintain a thriving colony of *E. fraterna* with the artificial diet

and procedures mentioned above for 6 successive generations. As a contrast laboratory colony maintenance of this insect did not succeed beyond a paltry 2–3 generations when the natural diet, castor leaves, were employed. Better nutrition and greater freedom from polyhedrosis virus in case of the artificial diet reared insects can be surmised as the resons for their better survival.

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A NEW SPECIES OF THE SPIDER OF THE GENUS *ZYGOBALLUS* PECKHAMS, 1885 (SALTICIDAE) FROM INDIA

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A **new species of the spider namely** *Zygoballus citri* **sp. nov. collected amongst the leaves of** *Citrus sinensis* **Osbeck is described and illustrated.**

The spiders of the genus *Zygoballus* Peckhams of the family Salticidae are little known members of Indian fauna. Only two species of this genus namely *Zygoballus pashanesis* Tikader and *Z. parmadaensis* Tikader have been described from this region (Tikader, 1975).

While examining the spider collection made during the survey of spiders predaceous on insect pests of fruit trees from Ludhiana, a new species was encountered which is described here as *Zygoballus citri* sp. nov.

Zygoballus citri sp. nov. (Figs. 1–6)

Female : Carapace : length 2.60–2.90 mm, broadest width 2.80–3.00 mm, reddish brown with a squarish black area behind the anterior row of eyes; narrow both anteriorly and posteriorly; widest behind the middle of its length; lateral sides circular; beset with white intermixed with black silky hair in the ocular region; thoracic region sloping abruptly from behind the posterior lateral eyes. Eyes : in three rows, those of the first row white and of the second row black, first row slightly recurved. Diameter of eyes : A.M.=40 mm, A.L. = 0.16–0.18 mm, P.M. = 0.05 mm, P.L. = 0.16—0.17 mm, Mutual distance between the eyes; A.M.—A.M.= 0.08—0.10 mm, A.M.—A.L. = 0.10—0.15mm, P.M.—P.M. = 1.60 — 1.70mm,

P.M. — P.L. = 0.90—1.05 mm. Posterior median eyes much nearer to anterior laterals than to the posterior laterals; ocular area wider than long, wider behind than infront and occupies more than half the length of carapace. Clypeus: width=0.15—0.20 mm dark brown, beset with whitish silky hair.

Chelicerae: dark brown, promargin with two unequal teeth, second tooth larger than the first, retromargin with a single tooth; promargin provided with a scapula and retromargin with a similar group of black hairs.

Labium: brown beset with blackish hairs at the anterior margin; longer than broad; reaching up to more than half of the length of maxillary lobes.

Maxillary lobes : brown, club-shaped with scopulae of black hairs on the inner margins. Sternum : brown, oval, truncated at the anterior end and narrow at the posterior end, beset with a few black setae.

Legs : first pair of legs heaviest and much stouter than others; beset with dense growth of blackish hairs particularly on the under side. Tibia armed with three pairs of ventral spines and a median spine anterior or these pairs; rest of the legs light brown, annulated with dark brown, sparsely covered with hairs;
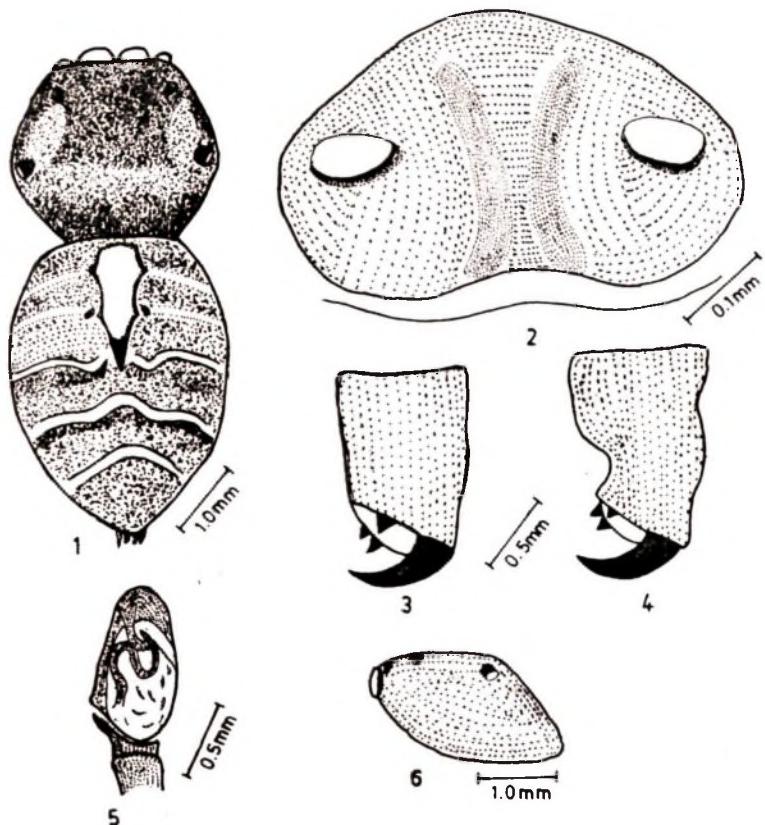
Figs. 1–6. *Zygoballus citri* sp. nov. 1. Dorsal view of the cephalothorax and abdomen of female. 2. Ventral view of apigynum. 3. Inner view of chelicera of female. 4. Inner view of chelicera of male. 5. Ventral view of palpal organ. 6. Lateral view of cephalothorax of female.

proximal ventral margin of coxae notched, tips of tarsi black; tarsal claws two, anterior superior claw with five teeth and posterior superior claw with fourteen teeth, claw tufts conspicuous. Length of legs: I, 5.95 mm; II, 4.80—4.95 mm; III, 4.25—4.60 mm and IV, 5.80—5.90 mm.

Abdomen : length 3.80—3.90 mm, broadest width 2.85—3.95 mm, yellowish with a median brown band in the anterior half; dorsum with transverse, wavy or broken whitish bands beset with sparse black setae. Venter creamish-yellow with a median broad and longitudinal brown band, anterior and posterior pairs of spinnerets slender and of equal length. Epigynum as in Fg. 2.

Male : carapace: length 2.45—2.85 mm, broadest width 2.90—3.10 mm; resembles female in colouration. Chelicerae greatly notched in the middle on the inner side and slightly towards the outer side. Labium, maxillary lobes and sternum dark brown. Resembles the female in the rest of the characteristics.

Pedipalps : palpal tibia sub-rectangular in shape having a small anterio-lateral spur on the outer margin; cymbium large and cup-shaped, sclerites fused to form a single bulb, receptaculum seminis visible through the bulb, embolus small and located at the distal end of the bulb, terminal apophysis bifid. First pair of legs heavier than those of female.

Abdomen : length 3.80—3.90 mm, broadest width 2.80—2.95 mm, reddish-brown, colour pattern more pronounced than female. The transverse bands on dorsum extend towards the venter to some extent.

Total length : female, 6.40–6.80 mm, male, 6.25—6.75 mm.

Holotype : Female, citrus orchard, Punjab Agricultural University, 5 kilometres south of Ludhiana, Punjab, India, Collected by G. L. Sadana on 12.xii.1989. Allotype: male, collection data same as for holotype.

Paratypes : 4 females and 3 males, collection data same as for holotype.

Types will be deposited in the National Collection of the Zoological Survey of India, Calcutta.

Habitat : Among the leaves of *Citrus sinensis* Osbeck.

Remarks : The present species resembles slightly *Zygoballus pashanensis* Tikader but can be distinguished from it in the following respects:

1. The promargin of chelicera bears two teeth.

2. The legs bear dark brown annulations.

3. The abdomen bears a median brown band in the anterior half of the dorsum.

4. The epigynum is markedly different.

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A NEW SPECIES OF *BEMISIA* (HOMOPTERA : ALEYRODIDAE) FROM INDIA WITH A KEY TO INDIAN SPECIES

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A new whitefly, *Bemisia capitata*, infesting the leaves of *Rivea hypocraterformis* (Desr) Convolvulaceae at Padappai, Tamil Nadu, India, is described.   A key to the Indian species of *Bemisia* is given.

(*Key words: Bemisisa capitata, Rivea hypocrateriformis,* Aleyrodidae)

Singh (1931) listed six species of *Bemisia* viz., *Bemisia giffardi* (Kotinsky), *B. leakii* (Peal), *B. grossa* Singh, *B. religiosa* (Peal), *B. achyranthes* Singh and *B. gossypiperda* Misra and Lamba, the last two species were subsequently reported as synonyms of *B. tabaci* (Gennadius) (Mound & Halsey, 1978). *Asterobemisia moringae* David and Subramaniam was assigned to the genus *Bemisia* and *B. jasminum* David and Subramaniam was also subsequently synonymised with *B. giffardi* by Mound and Halsey (1978). Bink-Moenen (1983) synonymised *B. hancocki* with *B. afer* (Priesner and Hosney).   With the addition of a species *B. graminis* David and Augustine (1988) the total number of species of *Bemisia* known from India has been arrived at eight; they being *B. afer, B. giffardi, B. grossa, B. leakii, B. graminis, B. moringae, B. religiosa* and *B. tabaci*.   In this paper, a new species *B. capitata* from *Rivea hypocrateriformis* is described.   Further, a study of the specimens of *B. leakii* and *B. grossa* loaned from the Division of Entomology, Indian Agricultural Research Institute, New Delhi shows that *B. afer* is a junior synonym to *B. leakii.*

KEY TO THE INDIAN SPECIES OF THE WHITE FLIES OF THE GENUS *BEMISIA* QUAINTANCE & BAKER 1914

1 Doral setae capitate ....*capitata* sp. nov.

- Dorsal setae not capitate 2

2 Setae on dorsum arising from distinct tubercles 3

- Setae on dorsum not arising from distinct tubercles 5

3 Submarginal setae varying in number and position; base of antenna with spines and vasiform orifice posteriorly with some transverse ridges ....*leakii* (Peal) 4

- Submarginal setae wanting ....

4 Elongate dorsal setae varying in number (including 13 pairs of dorsal setae) from none to seven depending upon the hairy or glabrous nature of leaf of host plant .... *tabaci* (Gennadius)

- Prothorax, metathorax and fourth abdominal segment each with a pair of setae; a pair of yellow pigment patch on abdomen, and caudal ridges yellowish.......................*religiosa* (Peal)

5 Dorsum with a pair of sublateral longitudinal tuberculate lines running all along the length of the body bearing four pairs of seate ....*giffardi* (Kotinsky)

- Dorsum without sublateral longitudinal tuberculate lines 6

6 Subdorsal setae on cephalothorax absent; asterisk like depressions one pair each on abdominal segments present; vasiform orifice without inner ridges ....*grossa* Singh.
- Subdorsal setae on cephalothorax present and vasiform orifice with innner ridges................. 7

7 Seven pairs of subdorsal setae-2 on the cephalothorax and 5 on the abdomen: submedian depressions present on the cephalothorax and

nsky
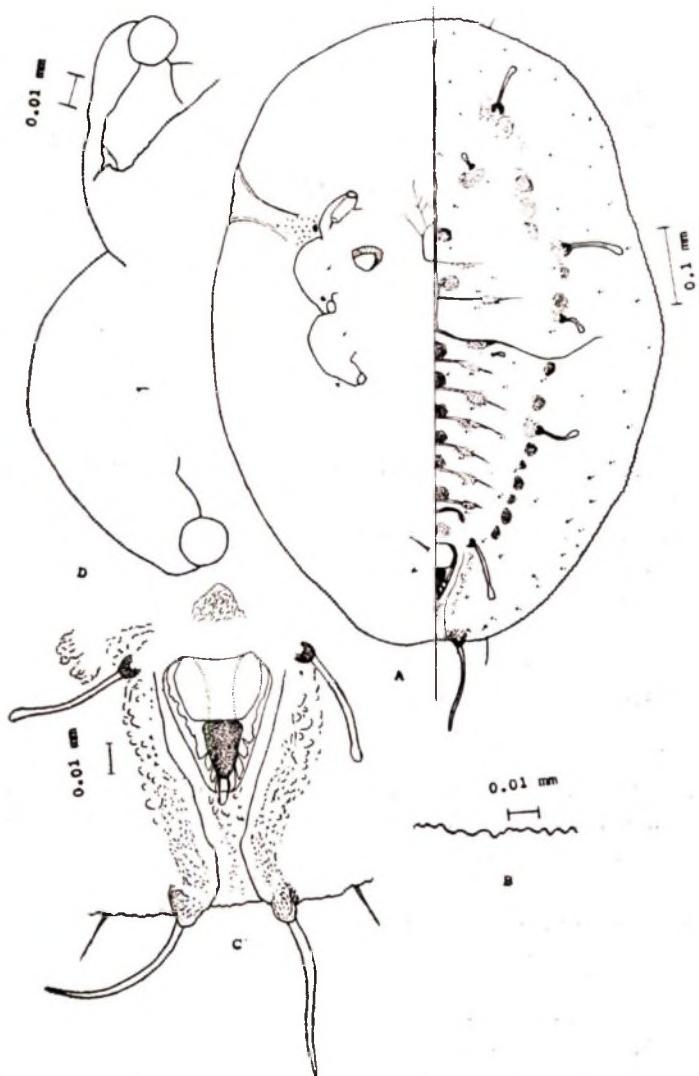
Fig. 1 *Bemisia capitata* sp. nov. A. Pupal case; B. Margin; C. Vasiform orifice with caudal furrow
D. Prothoracic and mesothoracic legs with antenna.

abdomen; vasiform orifice with 5–7 lateral
teeth .... *graminis* David & Augustine.

– Submarginal lines present; lateral part of abdo-
men granulated; vasiform orifice with 8 lateral
teeth..
...............*moringae* (David & Subramanaiam)

Bemisia capitata sp. nov. (Fig. 1)

Pupal case: White, without wax; ellip-
tical, broadest at the transverse moulting

suture area, deflexed at the thoracic tracheal
pore region, 0.81 – 1.02 mm long and 0.59
– 0.76 mm wide; found singly on the lower
surface of leaves. Cephalothorax 0.40–0.49
mm long and abdomen 0.41 – 0.53 mm long.

Margin: Irregularly crenulate; thoracic
and caudal tracheal pores or combs not indi-
cated; anterior and posterior marginal setae
10μm and 25μm long respectively.

Dorsal surface: Three pairs of capitate dorsal setae–cephalic setae 10–17.5μm long; first abdominal setae 5–7.5μm long; and eighth abdominal setae 55–65μm long. Often the cephalic and first abdominal setae are noticed to be minute and pointed in most specimens. Pointed caudal setae 75–80μm long. A row of four pairs of subdorsal capitate setae– a pair above the cephalic setae 52.5–65μm long; a pair laterad of mesothorax 47.5-75μm long and of metathorax 22.5–47.5μm long and a pair laterad of third abdominal segment 42.5–55μm long. Four pairs of small sub-marginal setae present on the abdomen 5–7.5μm long. Longitudinal moulting suture reaches the submarginal area and the transverse moulting suture reaches the base of the metathoracic leg. A pair of submedian depression present on all the thoracic and abdominal segment sutures including the transverse moulting suture. Pores and porettes sparsely distributed throughout the dorsal surface. A peripheral row of tubercles extending from the laterad of eighth abdominal segment to cephalic end on submedian area abdominal segments 1–6 and 8 with median tubercles and prothorax and mesothorax with submedian tubercles evident.

Vasiform orifice: Triangular shaped, 70–87.5μm long and 57.5–60μm wide with three to four pairs of lateral teeth. Operculum subrectangular, 30–40μm long and 42.5–52.5μm wide, lingula exposed setose (35μm long and 20μm wide) bears a pair of 12.5μm long setae sub-apically. Irregular dots on the laterad of vasiform orifice evident. Thoracic tracheal furrows not discernible while caudal tracheal furrow indicated, shorter than vasiform orifice, 52.5–77.5μm long and 15μm wide at the caudal end.

Ventral surface: Ventral abdominal setae 20–22.5μm long and 40–45μm apart. Antenna short and stout reaching the middle of the prothoracic leg, 37.5–42.5μm long. Tho-racic tracheal folds indicated with stipples at the interior near the legs while caudal tracheal fold indiscernible. A seta at the base of each meso- and metathoracic leg, 2.5μm long.

Material examined: **Holotype:** One pupal case mounted on slide, on *Rivea hypocrateriformis* (Desr.) (Convolvulaceae), Padappai (Tamil Nadu), 27.v.1989, Coll. K. Regu. **Paratypes:** Seventeen pupal cases on slides bearing the same details as of holotype; and many pupal cases on leaves in the collections of K. Regu. One paratype has been deposited in the collections of Division of Entomology, Indian Agricultural Research Institute, New Delhi.

This species differs from all other known species of *Bemisia* in having capitate dorsal setae.

Bemisia leakii (Peal) (Fig. 2 A and B)

This species can be recognised by spines at the base of antenna and transverse ridges near the posterior end of vasiform orifice. This species shows a great variation in shape, setae, dorsal and ventral structure. The study of the specimens of *B. leakii* loaned from the Division of Entomology, Indian Agricultural Research Institute, New Delhi shows that *B. afer* (Priesner and Hosney) is a junior synonym to *B. leakii* (Peal) due to the presence of spines at the base of antenna and transverse ridges near the posterior end of vasiform orifice.

Material examined: Six pupal cases on slides, on *Indigofera tinctoria*, Dalsing Serai, Bihar. 1902 (H. W. Peal).

Bemisia grossa Singh (Fig. 2 C and D)

This species can be recognised from the pupal cases with asterisk like submedian depressions one pair each on abdominal segments; long antenna and vasiform orifice
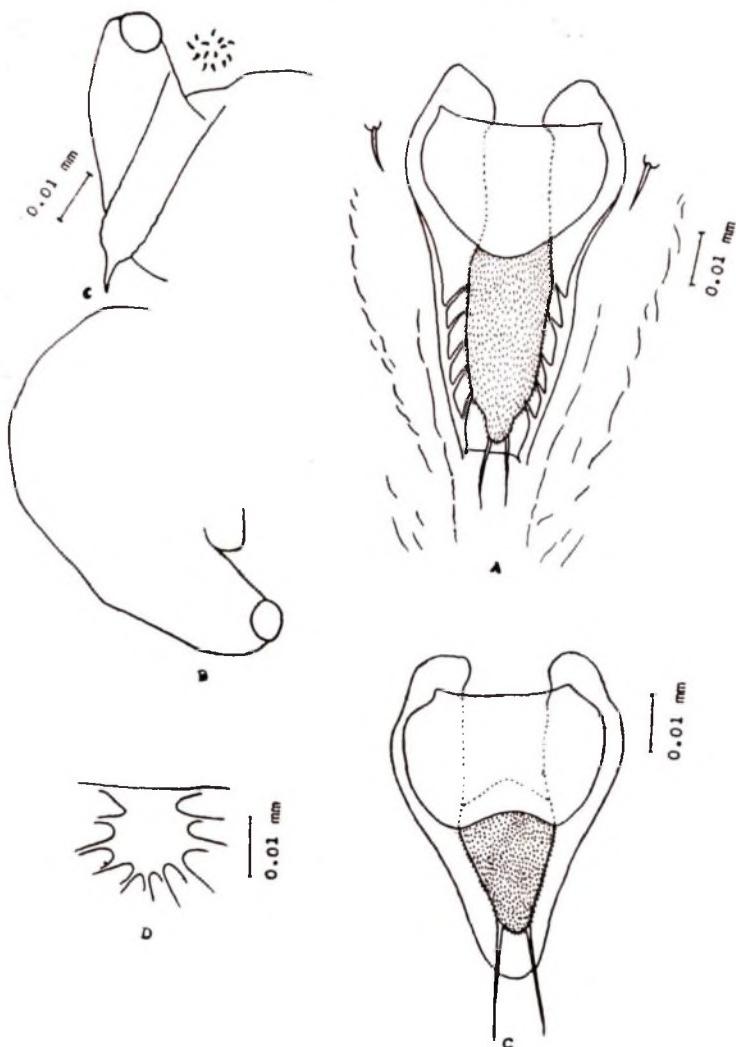
Fig.2 *Bemisia leakii* (Peal): A. Vasiform orifice; B. Prothoracic and mesothoracic legs with spines at the base of antenna; *Bemisia grossa* Singh; C. Vasiform orifice: D. Submedian depression.

triangular without lateral ridges, operculum subtrapezoidal with the caudal margin concave and the distal end of lingula conical shaped with a pair of long setae.

Material examined: Four pupal cases on slides, on *Eugenia operculata*, Dhanbad Bihar, K. Singh – loaned from the Division of Entomology, Indian Agricultural Research Institute, New Delhi.

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BRIEF COMMUNICATION

CONTROL OF *LIRIOMYZA BRASSICAE* RILEY BY FLOODING*

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Liriomyza brassicae **Riley is one of the important pests of Cruciferous plants in India. Observations of the effect of rainfall and flooding on the duration of various instars, mortality and related population fluctuations, indicate use of water as an alternate control agent without the use of insecticides that are enviromental pollutants.**

Brassica campestris L. is perhaps the most important oil seed cultivated in India. Leaf mining flies belonging to the Genera *Liriomyza* and *Chromatomyia* are responsible for on an average 38% of crop loss, the loss often going up to 80% (SINGH, 1988). *Liriomyza brassicae* Riley is a polyphagous species and is a major culprit of this loss. It is a hypsobiont species seen mostly associated with winter plants in the Gangetic plains. The species is also recorded from the higher elevations of Western ghats. The other cultivated plants attacked by these flies are *Pisum sativum, Brassica oleracea* var. *botrytis* and var. *capitata, Tropaelum majus* and many other wild plants.

Control of the leaf miners have always been a problem in the fields in the tropics although considerable amount of success have been achieved with chemical methods and parasites in the glass-house conditions in Europe (MINKENBERG & LENTERAN, 1986). A developing country like India, struggling to limit the environmental pollution to the minimum possible level, alternate methods of control will have to be evolved. The present study is an attempt in this direction. Water can be used for controlling the population of these flies effectively.

The adult females of L. *brassicae* Riley, deposit their eggs on the leaf tissue usually below the epidermis with the help of well developed ovipositor. The emerging I instar larvae tunnel through the leaf tissue and the II and III instar stages are also spent in the leaf tissue. The III instar, before pupation fall into the soil. The pupation as a rule takes place in the soil and the adult emerges from the soil to complete its life cycle (Table 1).

The figures show the effect of heavy rain on consecutive days on the I to III instars on the leaves of *Brassica campestris* L. in the field. The I instar shows maximum vulnerability to the rains, the entire population being killed by a single day's heavy rain whereas only 50% of the final instars are affected by one day's rain. Four days' continuous heavy rains totally destroyed all the III instars on the leaves. Only dead larval instars inside the mines are left after four days' rain. This amply shows the adverse effect of rain on the larval populations.

The last instar larvae of *Liriomyza brassicae* Riley fall into the ground for pupation. The emergence of the adult takes place from the soil. Table 2 shows the result of flooding on the pupae in soil. The pupae showed remarkable viability (100%) even

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*Contribution No. 326 from School of Entomology.

TABLE 1. Effect of rain on the instars on the leaves of *Brassica campestris* L.

Raining upto no. of days	Percentage of dead instars			% (total) mortality (average)
	I instar	II instar	III instar	
1	100	80	50	76.67
2	—	96	70	82.50
3	—	100	95	97.50
4	—	—	100	100.00

TABLE 2. Effect of flooding on pupal morality.

No. of pupae kept in water	No. of days in water	No. of adults emerged	No. of pupae dead	% of emergence	% of mortality
100	1	100	0	100	0
100	2	100	0	100	0
100	3	100	0	100	0
100	4	89	0	89	11
100	5	5	95	5	95
100	6	0	100	0	100

TABLE 3. Correlation between rainfall and life duration.

Yearly rainfall in mm	Life duration	Years of study
23.50	45.7 days	1984–85
76.70	40.2 days	1986–87
216.30	37.9 days	1985–86

after being submerged in water for 3 days. The mortality rate increased from 4 days onwards and 6 days submersion showed 100% mortality.

Increased rainfall is an adverse factor affecting also the duration of the instars and the total longevity duration show a decrease with increased rainfall as is evident from the field observations made during three sessions.

The observations (Table 3) and experiments clearly shows that heavy rains in the season could control the population of *Liriomyza brassicae* Riley effectively. Simulating rain

conditions through sprinklers may be gain-fully used. Where proper irrigation and drainage facilities are available flooding can also be used effectively to destroy pupae in the soil, 3–4 days flooding at the appropriate time before sowing can destroy almost 95% of the pupae in soil. Thus the use of chemical insecticides that causes a lot of residual problems can be totally avoided. Creation of adequate irrigation facilities with use of sprinklers will also increase the crop yield manifold.

ACKNOWLEDGEMENTS

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BRIEF COMMUNICATION

INFLUENCE OF PLANT GROWTH REGULATORS ON THE POPULATION OF THRIPS *CALIOTHRIPS INDICUS* (BAGNALL) AND DAMAGE IN GROUNDNUT

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The plant growth regulators maleic hydrazide, chlormequat chloride and naphthalene acetic acid were found to suppress thrips population considerably, but there was damage to foliage, indicating their insuitability in groundnut ecosystem, to control thrips.

The sesbania thrips *Caliothrips indicus* (Bagnall) is one of the major pests of groundnut causing considerable damage in groundnut (Amin, 1988). Many natural inducers like temperature, solar radiation, pesticides, and growth regulators were found to influence the resistance in crop plants (Kogan & Poxton, 1983). An experiment conducted with plant growth regulators (PGRs) maleic hydrazide (MH) and chlormequat chloride (Cycocell- CCC) at 500 and 1000 ppm and napthalene acetic acid (NAA) at 5 and 10 ppm resulted in interesting data which we lack in groundnut. Varieties raised in the pots (CVs. 'JL 24', 'GAUG 1,' 'GAUG 10' and 'M 13') were maintained free from pests on application of 0.05% monocrotophos till the first flowering. An interval of 10 days was given between the last spraying of insecticide and the spraying of PGRs, so as to avoid ill effects. PGRs were sprayed after pre-treatment count of the population from five leaves / plant in each of five plants at random. Two observations were made on the population after application of treatments at 15 days interval. Immediately after the second observation,

5 leaves/plant were selected from main and secondary branch starting from +2 leaf. The scraped area on the adaxial surface of the leaves was measured using tracing paper / graph paper and expressed in percentage. The data collected were analysed statistically. This study was conducted during 1987 post-rainy season.

The pre-treatment population of thrips did not differ significantly but the variation among the varieties justified as genotypic character (Table 1). Post-treatment observation after 15 days resulted in considerable reduction in the population in all the treatments compared to control ranging from 19.3 to 61.3 thrips/5 leaves in different varieties. Genotypic differences could not be detected. However, a highly significant difference in the population among the PGRs studied. The interaction effect between variety and PGRs, PGRs concentration, variety and PGRs and Concentration were highly significant. When we compare the percent population reduction, there was consistent decrease in all PGRs/ concentration compared to control in 'JL 24.' The reduction was in the range of 57.4 to 82.9 percent. In 'GAUG 1,'

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TABLE 2. Damage in leaflet due to different plant growth regulars.

Variety/ concentration		Percent area of leaflet scraping due to different PGRs				Varietal mean
		NAA	CCC	MH	CON	
	C_1	34.7	31.3	32.4	27.2	31.4
'JL 24'	C_2	28.6	34.5	32.3	25.4	30.2
	X_1	32.4	31.7	32.9	26.3	30.8
	C_1	28.9	29.2	31.6	22.8	28.1
'GAUG 1'	C_2	24.5	34.6	38.7	26.2	31.0
	X_1	26.7	31.9	35.2	24.5	29.6
	C_1	32.2	39.2	32.0	26.1	32.4
'GAUG 10'	C_2	29.5	38.5	30.3	25.7	31.0
	X_1	30.9	38.9	31.2	25.9	31.7
	C_1	39.0	34.1	28.4	24.9	29.9
'M 13'	C_2	26.4	29.5	40.6	21.0	29.4
	X_1	29.2	31.8	34.5	23.0	29.7
Mean		29.6	39.9	25.8	24.9	

Mean of 3 replications.

Comparison of significant effects CD: ($P = 0.01$) Between PGRs: 3.05.

C_1 = lower concentration; C_2 = higher concentration; X_1 = mean.

the highest population reduction (87.1%) was in the NAA at 5 ppm treated seedling and the least was in MH 1000 ppm. While the trend was quite different in spreading varieties i.e., 'GAUG 10' and 'M 13.' The increase in population at 1st fortnight followed by decrease in the second fortnight at 500 ppm in 'GAUG 10' could not be attributed to any reason. Surprisingly, there was corresponding increase in thrips numbers with decrease in concentration of NAA and CCC while, no such difference could be noticed in MH. With regard to leaf area damage, none of the PGRs found suppressing the feeding of thrips instead there was 19, 4 and 36 percent increase in leaf area damage due to NAA, CCC and MH respectively (Table 2). To conclude, though PGRs suppresses thrips population considerably, there was increased damage to foliage indicating their unsuitability in groundnut ecosystem wherever thrips are problem.

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TABLE 1. Population of thrips *Caliothrips indicus* under the influences of variety and PGRs.

Thrips population / 5 leaves in relation to variety and the influence of PGRs (ppm)

Variety	NAA 5			NAA 10			CCC 500			CCC 1000			MH 500			MH 1000			Control			Varietal mean
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	c
'JL 24' (SB)	49.3	19.3	10	43.7	16.7	9	35.3	20	12.3	38.7	23	16	23.7	16	13.7	32	17	30.7	49.3	61.3	72.0	29.0
		(−68.5)	(−81.1)		(−72.8)	(87.5)		(−67.4)	(−82.9)		(−62.5)	(−77.8)		(−73.9)	(−81.0)		(−72.3)	(−57.4)				
'GAUG 1' (SB)	24	11.7	5.7	54.7	19	18.7	38.3	29	26.3	35	25.7	29	23.3	26.7	33	34.7	31.7	30.7	28.7	36	44	28.8
		(−67.5)	(−87.1)		(−47.2)	(−57.5)		(−19.4)	(−40.2)		(−28.6)	(−34.1)		(−25.8)	(−25)		(−11.9)	(−30.2)				
'GAUG 10' (VR)	14.3	14	12.7	15.7	19.3	12	22	22.3	26.3	17.3	19	25	15.3	22.7	24	19.7	27	32.3	38.3	19.3	30.7	21.4
		(−27.5)	(−58.6)		(0.0)	(−60.9)		(15.5)	(−14.3)		(−1.6)	(−18.6)		(−17.6)	(−21.8)		(39)	(5.2)				
'M 13' (VR)	18.3	31.3	32.3	14	20.7	25.7	19.7	31	34	17.3	22.7	27.3	19.7	25.7	29.7	23.7	25.7	28.7	12	13.7	18.3	23.4
		(128.5)	(76.5)		(51.1)	(40.4)		(126.3)	(87.8)		(65.7)	(49.2)		(87.6)	(62.3)		(87.6)	(56.8)				
Mean	26.6	19.1	15.2	32	18.9	16.3	28.8	25.6	24.8	27.1	22.6	24.3	20.5	22.8	25.1	27.5	25.3	30.6	32.1	32.6	41.2	
		(−41.4)	(−63.1)		(−42)	(−60.4)		(−21.5)	(−39.8)		(−30.7)	(−41)		(−30.1)	(−39.1)		(−22.4)	(−25.7)				

CD = (*P* 0.01) : between PGRs 2.52; between variety × PGRs 5.04; between variety × PGRs × concentration 3.86; between PGRs × concentration 7.12.

* Data within parantheses indicate corresponding increase/decrease in relation to corresponding control of that period.

a, b, c represents pre, post treatment first and second observations.

BRIEF COMMUNICATION

NEW RECORDS OF SCALE INSECTS (HOMOPTERA: COCCOIDEA) AND HOST-PLANTS FROM KASHMIR VALLEY, INDIA

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Eighteen host plant species of six species of coccids from different localities of Kashmir Valley are given. Among them, four species of coccids are recorded for the first time from Kashmir. Besides, biological notes of coccids are added.

(Key words: coccids, host range, biological notes)

Earlier records of coccid fauna of Kashmir Valley have been given by Hassan (1937), Fotedar (1941), Zak-ur-Rab (1983), Varsheny (1984) and Masoodi & Trali (1987). During the course of present survey of scale insects, a few coccids have been encountered for the first time from Kashmir Valley, attacking a number of host plant species belonging to different families in various localities of this region. The various species of scale insects, with host range, field data and biological notes are given as under:

Family Coccidae

Sub-family : Coccinae

Tribe : Coccini

1. **Coccus hesperidium** (Linnaeus) (Fig.1)

1758. *Coccus hesperidium* Linnaeus, *Syst. Nat.*, 10th Ed., 1:455

1971. *Coccus hesperidium* : Ali *Ind. Mus. Bul.*, **6** (2): 24

Hosts: Cichorium intybus (Compositae), Zabervan, Srinagar, 18. vii. 1986; Cunnighamia sinensis (Toxodiaceae) (Green house plant), Kashmir University Botanical garden, Srinagar, 15. viii. 1986; Rosa brunoii and R. webbiana (Rosaceae), Bandipore, 25. vii 1986.

Biological notes: This soft brown scale insect has been found to occur in great abundance, damaging plants of protected cultivation as well as forest undergrowths. The insect remains active during summer season in the valley. The adult females were found infesting the stem and twigs of the host plant. In case of the plant, C. sinensis, the coccid attacked the underside of leaves.

2. **Eulecanium coryli** (Linnaeus) (Fig.2)

1758. *Eulecanium coryli* Linnaeus, *Syst. Nat.*, 10th Ed.

1896. *Eulecanium coryli* : Cockerell. *Bull. 111. Stat. Lab. Nat. Hist.*, **4**: 318-339.

Hosts: Cydonia oblonga (Rosaceae), Srinagar, 22.v. 1986: Berberis sp. (Berberidaceae), Perimahal, Srinagar, 14. viii. 1986; Cotoneaster aitchinsonii (Rosaceae), Tangmarg, 13. viii. 1986 ; Cotoneaster mumararifolia (Rosaceae), Kashmir University Botanical garden, Srinagar, 18. vi. 1986 ; Salix caprea (Salicaceae), Srinagar, 17. x. 1987.

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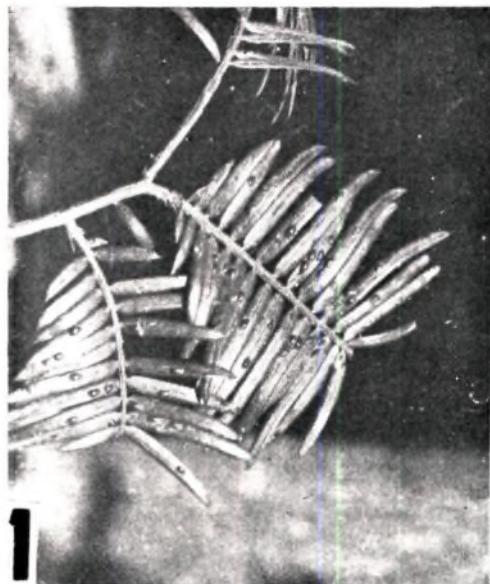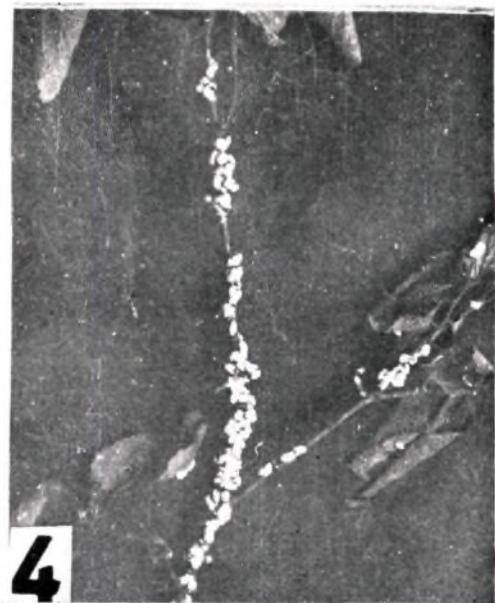
Fig. 1. *Coccus hesperidum* (L.) on the leaves of *Cunnigha.n.ia sinensis.* Fig. 2. High infestation of *Eulecanium coryli* (L.) on the branch and shoot of *Prunus domestica*. Fig. 3. Twig of *Populus caspica* infested with adult woolly coccid, *Pulvinaria* (*P.*) *borcheseenii* Danzig. Fig. 4. Severe attack of *Pulvinaria* (*P.*) *conspiqua* Danzig on the branches, twigs and leaves of *Celtis australis*.

Biological notes: The highly convex brown (dark) scales have been observed on the stem, branches and twigs of the host plant, including deciduous fruit trees in different regions and localities of Kashmir Valley. Many host plants showed the dormant stage of the scale, which was later found rapidly developing with the approach of warmer weather. The adult females remain active during late spring to late summer.

The heavy infestation of the host plants by the scale insect pest caused gall formation of branches of host plant, *Cydonia oblonga*. The branches and twigs of *C. aitchinsonii* and *Prunus domestica* were found to be severely damaged by the attack of *C. coryli* (L.) at many places of the Valley.

3. Parthenolecanium corni (Bouche)

1844. *Parthenolecanium corni* Bouché, *Stett. Ent. Zeitung.*, G.: 293–302.

1980. *Parthnenolecanium corni:* Danzig, *Coccids of the Far Eastern USSR*, Indian Ed., 317 p.

Hosts : Crataegus songarica (Rosaceae), Shankaracharya Hill, Srinagar, 14. vii. 1984; *Rubus analoticus* (Roasceae), Srinagar, 2. vi. 1986 : *Salix alpina* (Salicaecae), Srinagar, 2. vi. 1986: *Sophora japonica* (Papilionaceae), Pattan, 12.vi. 1986; *Viburnum foetans* (Caprifoliaceae), Srinagar 19.x. 1986: *Vitis vinifera* (Vitaceae), Srinagar, 20.v.1986; Unidentified plant, Kashmir University Botanical Garden, Srinagar, 28. v. 1986.

Biological notes : P. corni (B.) was found to infest various trees and shrubs in the valley for the first time. Heavy infestation was noticed on *V. vinifera* and *R. analoticus* rendering damage to these plants. Very small population of *P. corni* was seen on other host plant species. The coccid mainly

attacked the stem of the hosts, however, in case of *Rubus* infestation was found on the subaerial part of the plant.

Tribe: Pulvinarini

4. Pulvinaria (Pulvinaria) borchsenii Danzig (Fig. 3)

1978. *Pulvinaria (P) borchsenii* Danzig, *Tr. Biol. Pochv, in ta Dal nevest nauch tsentra AN SSR, n.s. w. s.*, **50** (153):17
1980. *Pulvinaria (P) borchsenii :* Danzing, *Coccids of the Far Eastern USSR*, Indian Ed., 314 p.

Host : Populus caspica (Salicaceae), Boulevard, Srinagar, 23.vi.1986

Biological notes: The white cushion scales were found in very few number on the twigs of *Populus* tree. This is the first record of the species from Kashmir Valley.

5. Pulvinaria (Pulvinaria) inconspiqua Danzig (Fig. 4)

1967. *Pulvinaria (Pulvinaria) inconspiqua* Danzig, *Tr. Zool. in ta AN SSR*, **41** : 146

1980. *Pulvinaria (P.) inconspiqua*: Danzig, *Coccids of the Far Eastern USSR*, Indian Ed., 313 p.

Host : Celtis australis (Celtaceae), Kokernag. 15. vi. 1986.

Biological notes: Huge infestation of this scale insect species was observed, damaging stem, branches and even leaves of the forest tree, *C. australis*. The coccid remained active in the field from late spring to early summer. This species is recorded for the first time from Kashmir Valley. A hymenopteran parasite belonging to the genus *Aphelinus* (Aphelinidae) was parasitic on the scale insect.

Sub-family : Diaspidinae
Tribe : Chionaspidini

6. Chionaspis furfura (Fitch)

1937. *Chionaspis furfura* (Fitch) : *Ferris, Atlas of the Scale Insects of North Americ., SI Standford Univ. Press.*

Host : *Prunus armeniaca* (Rosaceae), Peri Mahal, Srinagar, 15.vi. 1986

Biological notes: The scale insects were collected from the branches and shoots of *P. aremeniaca*. The population density was observed to be low. The adult females were found active in the month of June and July. This is a new record from Kashmir Valley.

ACKNOWLEDGEMENTS

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BRIEF COMMUNICATION

SOME RARE DEVELOPMENTAL ABNORMALITIES IN THE FEMALE REPRODUCTIVE ORGANS OF THE LEMON-BUTTERFLY, *PAPILIO DEMOLEUS* L. OCCURRING NATURALLY

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The occurrence of paired bursa copulatrix and paired spermathecae with all their components duplicated on the two sides in an adult female of *Papilio demoleus* has been reported. An additional bursa referred to as an ectopic bursa copulatrix has also been reported in another individual. These freaks seem to represent a very rare phenomenon not reported in any other insect.

(*Key words*: developmental abnormalities, female reproductive organs, *Papilio demoleus*)

In normal adults of *P. demoleus*, as in all higher Lepidoptera, the bursa copulatrix and spermatheca are unpaired organs (Fig. 1). But in one individual of this insect, we found both these organs in a paired condition (Fig. 2). The paired bursae, however, open externally by a single ostium bursae but through two ductus bursae that posteriorly join to form a common ductus bursae. The right ductus bursa is relatively shorter than the left one and on slit-opening the corpuses of the two bursae, a spermatophore could be recovered only from the right corpus. This spermatophore, otherwise normal in form, is smaller than that deposited in a normal insect (Fig. 3). The paired spermathecae, though getting damaged during the dissection, could still be distinguished into their usual components *viz.*, the spermathecal sac, spermathecal duct and spermathecal gland. Despite the paired nature of the spermatheca, only one seminal duct runs between the median oviduct and junction of the two ductus bursae. One more abnormality that we encountered in another individual is the occurrence of an ectopic bursa copulatrix — ecto-

pic because of its being wrongly positioned on the indigenous bursa. The ectopic bursa copulatrix is deformed due to its having a short ductus that is attached to the corpus of the indigenous bursa while its own corpus gets divided by a flexure into a right and a left arm (Fig. 4). The bursa nature of this organ is nonetheless evident from the chitinous signum present ventrally on its left arm (so not visible in Fig. 4). The signum is a typical bursal feature of all higher Lepidoptera.

Amongst insects, developmental abnormality such as the occurrence of a detached and undeveloped ovary has been reported in natural populations of some bugs (PLUOT, 1973; REGIS, 1977). Some developmental abnormalities in the gonads have also been induced surgically by severing the lateral oviduct (PANTELOURIS, 1955) and by application of juvenoids (MASNER *et al.*, 1963; ROHDENDORF & SEHNAL, 1972; KATIYAR & SRIVASTAVA, 1982; CHAKRAVORTY & CHOUDHURY, 1986). But none of them is similar to the ones being reported here. Another feature that merits attention is the presence of spermatophore only in the right bursa. This

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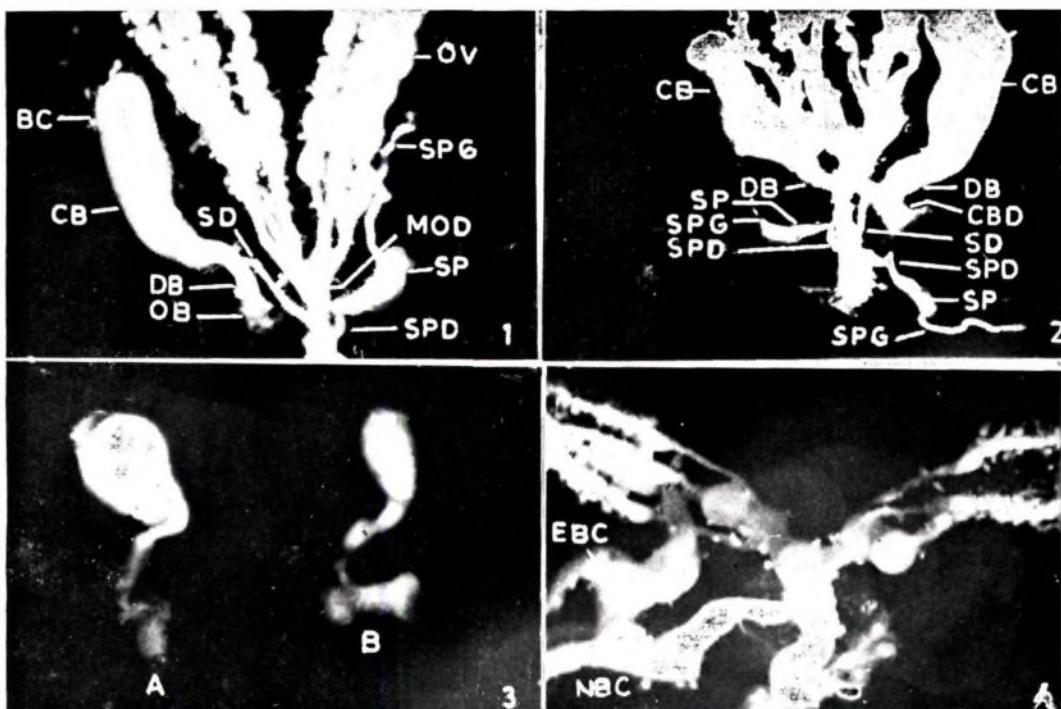
Fig. 1. WM (whole mount) of the normal female reproductive organs. BC, bursa copulatrix; CB, corpus bursae; DB, ductus bursae; MOD, median oviduct; OB, ostium bursae; OV, ovary; SD, seminal duct; SP, spermatheca; SPD, spermathecal duct; SPG, spermathecal gland. ×23. Fig. 2. WM of the abnormal female reproductive organs with paired bursa copulatrix and spermathecae. CDB, common ductus bursae. Other lettering same as in Fig. 1. ×23. Fig. 3. WM of the normal spermatophore (A) and diminutive spermatophore from the right (paired) bursa copulatrix (B). ×23. Fig. 4. WM of the abnormal female reproductive organs with a normal bursa copulatrix (NBC) and an ectopic bursa copulatrix (EBC) imposed on it. ×23.

may be a chance occurrence but more likely could also be due to the ability of the male to establish a correct aedeagal alignment with the right ductus bursa only. The smaller size of the spermatophore points to an insufficient deposition of the male secretions possibly due to an early withdrawal of the aedeagus as a result of the inconvenience caused by the shortness of the common ductus bursae. The above mentioned freaks seem to represent a very rare phenomenon not reported in any other insect.

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BRIEF COMMUNICATION

THE NESTING AND PROVISIONING BEHAVIOUR OF A POTTER WASP (*EUMENIDAE*) : AN ETHOLOGICAL ANALYSIS

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The nesting and provisioning behaviour (post-copulatory reproductive behaviour) of the common potter wasp *Delta conoides* is described and analysed into 6 components in the light of our present day knowledge of ethology.

This paper deals with our observations on the nesting and provisioning behaviour (post-copulatory reproductive behaviour) of the common potter wasp (mason wasp), *Delta conoides* Gmelin (Eumenidae) and its ethological analysis. HINGSTON (1926) made a detailed study of the architecture, the architectural problems and of the *instincts and intelligence* of this species of wasp at Fyzabad (U. P., N. India). But an attempt to analyse the nesting and provisioning behaviour of this wasp in the light of our present day knowledge of ethology, is here being made for the first time. These observations were made in September 1988 in the first author's house in Trichur and are based on the behaviour of 2 females. One of these built its nest consisting of linearly arranged brood cells (Fig. 4) on the vertically hanging end portion (40 cm long and 3.5 cm wide) of a canvas belt. The second wasp made a nest consisting of semi-spherically arranged brood cells (Fig. 1) located on the concave front side of one of the aluminium blades of a pedestal fan. As *D. conoides* is a fairly large sized insect (about 2.8 cm long), its nesting and provisioning behaviour could be observed from close quarters with the unaided eye and photographed.

A. *Nesting and provisioning behavior : ethological components*:

The nesting and provisioning behaviour of this wasp can be divided into 6 different components, the first one leading to the second the second to the third, and so on, in sequential order.

1. *Nest site selection* :

The final choice of a spot for location of the nest is made only after repeated reconnaissance flights. During this flight, the wasp produces a very characteristic humming sound. After the selection is made, the wasp appears to 'study' the position of this site with respect to its surroundings (such as : the position of other objects in the room, for example, of furniture, doors, windows, etc.) so as to facilitate its future orientation to the same site.

2. *Brood cell construction* :

The wasp now flies to a nearby wet area in the open, mixes clayey soil and manipulates it into a mud pellet on the average 5 mm in diameter, by means of the mandibles, other mouthparts and the foretarsi. The

pellet of mud is then transported in flight, held by the mandibles and the forelegs, to the selected nesting spot. During this transportation flight also the humming sound is produced by the wasp. The first mud pellet is spread out in an arc by the use of the long and flat mandibles and other mouthparts, these being employed like a mason's trowel. The floor of the brood cell is mostly formed of the substratum on which the cell is located. The wall of the brood cell is made from pellets which are transported one after the other and worked up to form a roof arching towards the centre till a small rounded aperture is left just, large enough to permit the wasp to introduce its head or abdomen into the brood cell. The wasp then works upwards the rim of this aperture to form a funnel and later folds its distal portion outwards so that the cell now resembles the shape of the upper half of a typical South Indian water pot (Figs. 1 & 3). The conspicuously everted rim of the brood cell shows impressions made on its upper surface by the antennae and the mouthparts (especially the mandibles and the glossae) used to manipulate this part of the cell. The outer margin of the everted rim of the brood cell is drawn out into subdigitiform processes. Nine pellets of mud, on the average, are required for the construction of a broad cell. Hingston (opt. cit) reported 15 mud pellets as the average number required for this prupose in the wasp he observed. Each brood cell is somewhat elliptical in outline when viewed from above but is semi-ovoid in shape in lateral view (Fig. 3). An average sized brood cell is 2.5 cm long, 2 cm wide, 1 cm high and has a volume of 2.8 cm^3.

3. *Oviposition* :

The completion of the work of the brood cell construction acts as a stimulus which releases the next important act, that of oviposition. The wasp introduces the tip of its abdomen into the opening of the brood cell and in about 4 minutes, time, oviposition is accomplished. The sausage-shaped pale yellowish egg (length 4 mm, maximum width 1.5 mm) hangs by a thin silken thread fixed to the inside top portion or the wall of the brood cell (Fig. 2).

4. *Provisioning* :

The consummation of oviposition and the sight as well as the smell of the egg act as stimuli for the release of the next behavioural component, viz., provisioning of the brood cell. The wasp now flies out to hunt for eaterpillars (usually green) of the family *Geometridae*. On finding one of the appropriate sage, the wasp repeatedly stings it from below the prothoracic region. After the caterpillar is paralysed, the wasp catches hold of it in its neck region by means of her mandibles and in the thoracic region means of her fore legs. It now flies to its brood cell transporting the paralysed caterpillar, the long abdomen of which trails behind and below the wasp's abdomen. During this flight the wasp produces a louder humming sound than during the earlier two occasions (see above). It now alights on the rim of the brood cell opening and slowly slips the paralysed caterpillar into the bottom of the cell (Fig. 3). The sight and smell of the egg hanging from the roof of the cell continue to stimulate the wasp to bring in more paralysed caterpillars of similar type one after the other and slip them into the cell. This way, depending on the size of the caterpillars some 6 – 9 of them are stowed in (mass provisioning). The mass of paralysed caterpillars inside the cell now hide the wasp's egg from her view and the stimulus for further provisioning wanes.

5. *Closing the brood cell* :

The cessation of provisioning now acts as a stimulus for the wasp to seal off the
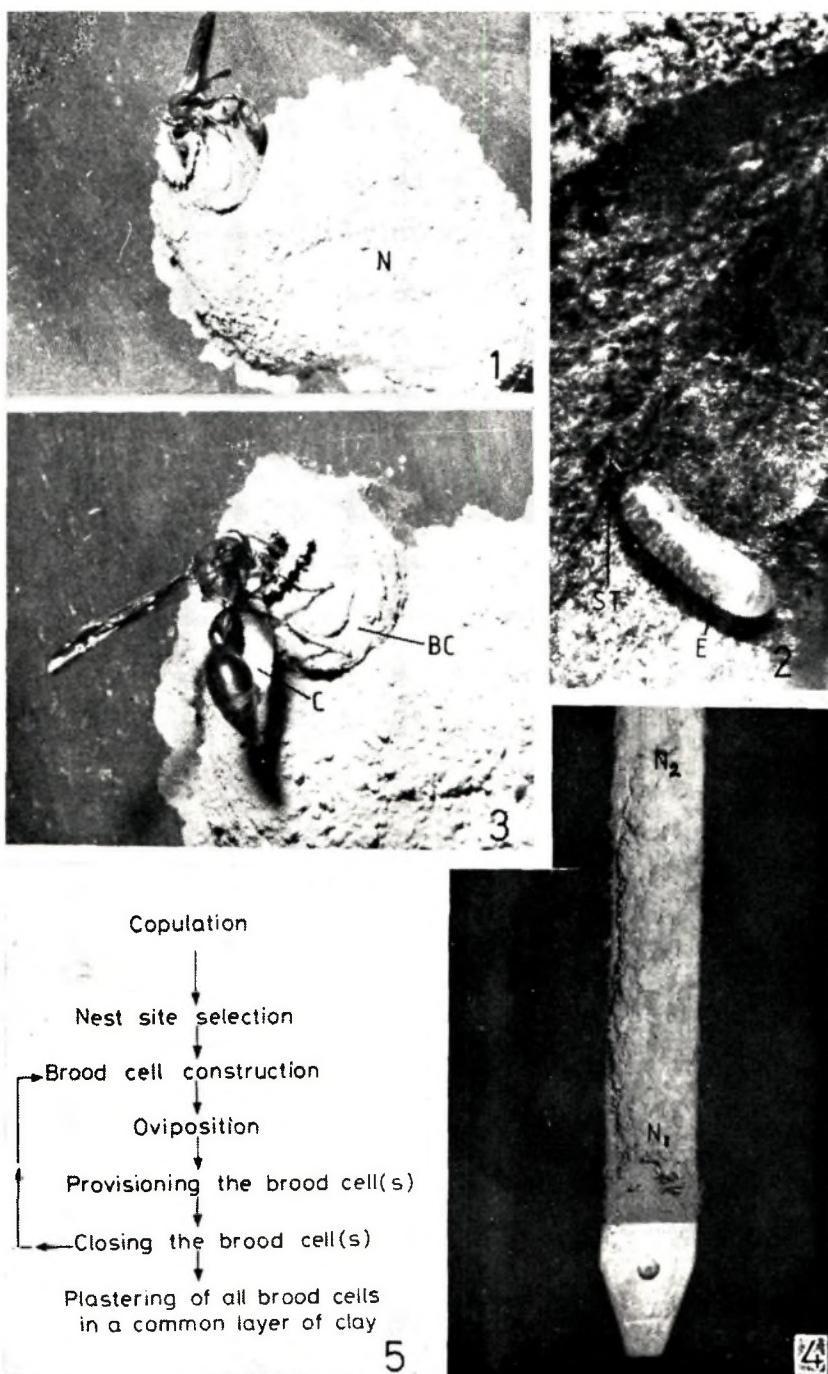
Fig. 1. Nest of *Delta conoides* consisting of semi-spherically arranged brood cells located on the blade of a pedestal fan. An additional brood cell was then constructed on one side of the nest. Here the wasp is in the final stages of embellishment of the everted rim of the opening of the brood cell. N = Nest. Fig. 2. The sausage-shaped egg of *D. conoides* attached by a thin silken thread to the inside top portion of the brood cell. e, egg; s.t., silken thread attachment. Fig. 3. The wasp slipping one of the several paralysed geometrid caterpillars into its brood cell. BC, Brood cell; C, Paralysed caterpillar. Fig. 4. Nest of *D. conoides* consisting of linearly arranged brood cells located on a vertically hanging canvas belt. N_1, position of the first and oldest brood cell; N_2, position of the last and youngest brood cell in the nest. Fig. 5. Flow chart representing the stimuli – response reaction chain directing the nesting and provisioning behaviour in *D. conoides*.

opening of the provisioned brood cell with a thin lid made out of a mud pellet specifically brought for this surpose.

The closed brood cell now acts as a stimulus (see the feed-back arrows) (Fig. 5) for the wasp to construct the second brood cell. Upon completion of the second brood cell, the wasp oviposits, provisions it and seals it off as before. The feed-back stimulus operates untill all the eggs of the wasp are laid in separate brood cells, provisioned and sealed off. The number of brood cells made may vary from 7 to 10 or more.

6. *Plastering of all the brood cells in a common layer of mud :*

When all the brood cells have been sealed off, the finished structure acts as stimulus for the wasp to undertake the work of plastering of all her brood cells evenly in a protective layer of mud, sometimes with an admixture of cow-dung This final product may be termed the 'nest'.

B. *Ethological analysis :*

The entire sequence of behavioural repertoire from nest site selection to brood cell construction to oviposition to provisioning and closing of the brood cell(s) to plastering of all the brood cells in a common layer of mud, were found io proceed in the principle of the reaction chain in ethology, based on a series of stimuli acting as specific releasers

of specific responses (LORENZ, 1937, 1956; TINBERGEN, 1948, 1951; THORPE, 1951). beginning with the stimulus of the copulatory act), as shown in Fig. 5.

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REPORTS AND NEW RECORDS

MACONELLICOCCUS HIRSUTUS ON POMEGRANATE

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Maconellicoccus hirsutus (Green) was recorded for the first time on pomegranate.

(*Key words*: first record, *Maconellicoccus hirsutus*, mealybug, pomegranate)

Pomegranate (*Punica granatum* L.) is prone to attack by many insects throughout the world. About 45 insects have been reported to be injurious to pomegranate in India alone (Butani, 1976). Of late, mealybugs have become an increasing threat on pomegranate (Mani & Krishnamoorthy, 1989). During the search for the natural enemeis of the mealybugs in March 1989, the pink mealybug popularly also known as Hibiscus mealybug *Maconellicoccus* (= *Phenacoccus*) *hirsutus* Green was observed infesting stem, flowers and fruits of three-year old pomegranate plants at Block No. 9 of Indian Institute of Horticultural Research Experiment Station, Bangalore. All stages of the mealybug were observed on the plant parts. Severe infestation led to dropping of flowers, and the mealybug infested fruits were made unfit for marketing. We could not observe any natural enemy on *M. hirsutus*, perhaps due to frequent application of methyl parathion.

According to Ghose (1972), *M. hirsutus* is a polyphagous feeder infesting more than 125 plant species. Search for the literature has revealed that *M. hirsutus* appears to be first record on pomegranate, since it has neither been reported from India nor from other countries (Mani. 1989).

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BOOK REVIEW

BEEKEEPING, By L. R. VERMA, Published by Oxford & IBH Publishing Co., Pvt. Ltd, Hard-bound, Rs. 260/–, 367 pp., 1990.

The full title of the book is more than meets the eye; it is : "BEEKEEPING in Integrated Mountain Development: Economic and Scientific Perspectives". In this excellent monograph prepared with the support of International Centre for Integrated Mountain Development, and written by Dr. L. R. Verma, an authority on different aspects of beekeeping and with over twenty years experience in this field of research, the author, while reviewing the state-of-the-art in Beekeeping, has covered such diverse aspects of this important but rather neglected subject as : its importance in mountain farming systems, in integrated rural development, in mountain crop productivity, status and economics of beekeeping in the Hindu Kush-Himalayan countries (viz., northern India, Pakistan, Bangladesh, Nepal, Bhutan, China, Burma), apicultural practices, hive products, different Species of honeybees, their biology and management, as well as origin, evolution and cytology of Asian Honeybees; and honey plant resources in the region. It has an Epilogue of ten pages and a fairly extensive collection of References of 34 pages and an Index of 17 pages. Eighty seven tables cover voluminous data on various aspects; there are also nineteen figures especially of details of different beehives and of systematic characteristics of the bees which will be of considerable interest to many users. The book, while relating the present status of beekeeping in the Hindu Kush-Himalayan region, gives excellent suggestions and indicates future scope and strategies for further development at the same time pointing out how far behind the beekeeping practices in this region are when compared to those in advanced countries. The author maintains with support from rather extensive data, that beekeeping has in this region not received the attention it deserves, and points out what it can do in such fields as agriculture, horticulture and forestry; his timely rejoinder that without improvement of the present apicultural pracices, the considerable efforts and money invested in these areas are likely to give no proportionate returns, will be an eye opener to our planners. Pesticides employed might not be of much use if they kill the honey bees also, which are necessary for pollination of crop. Enough honeybees are necessary for fruiting of orchards; other inputs supplied may be of no use if this bottleneck is not removed. The author maintains in the book that beekeeping can play a vital role in integrated rural and mountain development in this region especially in imporoving the lot of the poor villager and tribal people because it can be non-lad-based source of income with only limited expenditure and also because at present it is one of the most under-utilised and almost unexploited resources in this extensive landmass, offering tremendous potential and scope for development. Recourse to modern apicultural practices can improve the income generated from commercial apiculture to an astounding degree However, the author is quick to point out not only the prospects but the problems as well, of such innovative practices as introduction of the European *Apis mellifera* in the region, not only to apiculture but to flora and fauna and ultimately to the ecology

of the region and at the same time stressing the need for cautiously replacing traditional methods by modern scientific methods to improve the output qualitatively, as well as quantitatively, and the various constraints involved in this. The book is thus of importance and of considerable use not only to entomologists in general and apiculturists in particular, but to agri-horticulturists, orchardists, silviculturists, planners, economists as well as to extension workers and to environmentalists. Hard-bound and beautifully brought out, with very few mistakes, the book, at Rs. 260/-, is moderately priced and affordable and will be an asset and should find a place in any good library.

V. K. K. PRABHU

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SYMPOSIUM POSTPONED

The International Symposium on Tropical Crop Research and Biotechnology, which was scheduled to be held in September 1991, stands postponed to September 1992.

For further details, please contact: Secretary, ISTCRAD, P. B. No. 2210, Trivandrum 695 010, India.

Secretary
ISTCRAD

AUTHOR INDEX

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